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Hardware vs. Manpower Comparability Methodology

Step 2: Manpower Requirements Analysis
Volume 3

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Manned Systems Group
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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Army Hardware vs. Manpower (HARDMAN) Comparability Methodology (HCM) is a six-step process for determining a weapon system's manpower, personnel, and training (MPT) requirements. It provides a structured approach for early MPT estimation based on comparability analysis, an analytic system that uses knowledge about similar existing systems and technological growth trends to project the MPT requirements of proposed new systems. The HCM's six interrelated steps are Systems Analysis, Manpower Requirements Analysis, Personnel Pipeline Analysis, Training Resource Requirements Analysis, Impact Analysis, and Tradeoff Analysis. The HCM has been successfully applied to a range of weapons systems, including air, armor, artillery, infantry, air defense, command and control, and intelligence systems.

The Product Improvement Program for HCM made major revisions to the existing HCM Guide. The scope has been expanded to include several new areas; existing procedures have been revised, refined, and clarified; and the entire Guide has been rewritten to achieve greater clarity, consistency, and completeness.

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19. ABSTRACT (Continued)

This volume addresses manpower requirements of operators and maintainers. The required Military Occupational Specialties (MOS) and Additional Skill Identifiers (ASI) are identified and the total requirements of each are determined in this step.

Research Product 90-19C

Hardware vs. Manpower Comparability Methodology

Step 2: Manpower and Requirements Analysis
Volume 3

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FOREWORD

The goal of the Army HARDMAN methodology is to provide timely information on the manpower, personnel, and training (MPT) resource requirements of emerging weapon systems. This information supports decisions on the research, development, and acquisition issues affecting emerging systems, as well as planning required for effective supportability of these systems in MPT and logistics areas. HARDMAN is a key element of the Army MANPRINT program.

This guide consists of seven volumes, a manager's guide and one volume for each of the six steps of the HARDMAN methodology. The manager's guide is intended for the use of the manager in the planning, scoping, and costing of the HARDMAN analysis. The other six volumes are for the analysts who will perform the analytic procedures in each step of the methodology.

This volume is the manager's guide. It deals with the planning and conducting of the HARDMAN analysis and the estimation of the resource requirements for the analysis. Development of the quality assurance plan and the consolidated database are explained. The relationship of HARDMAN results to various Army MPT documents is also discussed.

This guide is a major revision and expansion of the existing five-volume HARDMAN guide. The scope has been altered to include procedures for assessing combat damage workload and depot-level manpower requirements, and estimating training resource requirements associated with new training concepts and other procedures not included previously. Existing procedures have been clarified, simplified, or expanded to make them more useful to the analyst and to make HARDMAN a more effective tool for the Army.

The development of the guide was part of the System Research Laboratory's Third Generation MANPRINT Estimation Research Task. Most of the expansion and enhancement of the HARDMAN method has been based on recommendations of the Soldier Support Center, National Capital Region (SSC-NCR), which has overseen application of the method to numerous Army weapon systems. Staff from the SSC-NCR attended all the in-progress reviews for this effort and have been briefed on the final product. In addition, personnel from the TRADOC Analysis Command, White Sands Missile Range, TRADOC Headquarters, the U.S. Army Human Engineering Laboratory, and other Army agencies have been briefed on the revised HARDMAN guide to make them aware of its enhanced capability to provide MPT information for emerging systems.

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HARDWARE VS. MANPOWER COMPARABILITY METHODOLOGY (STEP 2: MANPOWER REQUIREMENTS ANALYSIS) (VOLUME 3 OF 7)

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INTRODUCTION

"Manpower Requirements Analysis" is the second step in the Army HARDMAN Comparability Methodology (HCM). The HCM is a Manpower and Personnel Integration (MANPRINT) tool that addresses manpower, personnel, and training (MPT) issues associated with new or improved weapon systems.

This document is one of seven documents that contain the steps necessary to conduct an HCM analysis:

"Overview and Manager's Guide"

"Step 1: Systems Analysis"

"Step 2: Manpower Requirements Analysis"

"Step 3: Personnel Pipeline Analysis"

"Step 4: Training Resource Requirements Analysis"

"Step 5: Impact Analysis"

"Step 6: Tradeoff Analysis"

How this Document Is Organized

An HCM step consists of an overview and substeps. A substep contains an overview and action steps. Each action step includes a discussion of what the analyst will accomplish in the action step; procedures that describe, step-by-step, how to accomplish the action step; and examples that feature actual Army systems. The table on the following page summarizes the procedures a manpower analyst must undertake to accomplish this HCM step.

Worksheets are used extensively throughout the guide. These worksheets help the analysis team organize and format information and serve as an audit trail of the analysis. Blank copies of these worksheets are located at the end of each substep.

Each HCM step has its own unique appendices. These appendices include articles that provide additional information about the step; a list of acronyms; a glossary; a crosswalk between the HCM and the Man Integrated Systems Technology (MIST); and a crosswalk between the HCM and MPT-related Army documents, for example, Basis of Issue Plans (BOIPs) and the Qualitative and Quantitative Personnel Requirements Information (QQPRI). (Each step's appendix section does not include a list of references. The "Overview and Manager's Guide" includes a complete list of references for all seven volumes.)

Step 2's Substeps and Action Steps

IN THIS SUBSTEP	THE ANALYST WILL	BY COMPLETING THIS ACTION STEP
2.1	Determine MOSs, ASIs, and Duty Positions	Determine the Operator MOS, ASIs, and Duty Positions Determine Maintainer MOSs/ASIs
2.2	Determine Force Structures	Determine Steady-State Force Structures Determine Deployment/ Retirement System Distribution
2.3	Determine Maintainer Manpower Requirements	Calculate Each Component's Direct Maintenance Workload Review Maintainer MOS Requirements Assign Maintenance Workload to the Maintainer MOSs, ASIs, and Paygrades Determine Available Productive Man-Hours for Each Maintainer MOS and Each Depot Determine Maintainer Manpower Requirements Determine Maintainer Manpower Requirements for System Deployment/Retirement Schedules Determine the Impact of Combat Damage on Maintainer MOSs

Step 2's Substeps and Action Steps (Continued)

IN THIS SUBSTEP	THE ANALYST WILL	BY COMPLETING THIS ACTION STEP
2.4	Determine Operator/Crew Manpower Requirements	Determine Operator - Task Timelines for Each Mission Event Calculate Each Mission Event's Operator Workload Identify Operator MOS Requirements Assign Operator/Crew Workload to the Operator MOS, ASIs, and Duty Positions Determine the Operator MOS's Available Productive Man-Hours Determine Operator/Crew Manpower Requirements Determine Operator/Crew Manpower Requirements for System Deployment/Retirement Schedules
2.5	Determine Non-Workload-Driven Manpower Requirements	Identify Standard-Position, Supervisory, and Policy-Driven Manpower Requirements

STEP 2
MANPOWER REQUIREMENTS ANALYSIS

Overview

In Manpower Requirements Analysis, Step 2 of the HARDMAN Comparability Methodology (HCM), the manpower analyst determines the qualitative and quantitative manpower requirements of the Predecessor System, Baseline Comparison System (BCS), and Proposed System. Figure 2-1 is an overview of Step 2.

The analyst defines the qualitative aspects of the manpower analysis in the first two substeps. These qualitative aspects are the MOSs that will operate and maintain the New System and the force structures in which the New System will be deployed.

The analysis scope will dictate whether the analyst must determine a total system density or a detailed force structure that describes where each New System will be deployed. If the analyst must develop a complete force structure, he or she must describe each unit that will receive the New System and how many systems the unit will receive. The analyst can then determine the manpower requirements of each unit receiving a New System.

In Substeps 2.3 and 2.4, the analyst calculates the quantitative aspects of manpower: that is, the number of soldiers needed in each qualitative category to operate and maintain the New System.

The analyst uses the maintenance ratios developed in Substep 1.9 to determine the maintenance workload for each piece of equipment at each maintenance level in each configuration of the system. The analyst then assigns this workload to the maintainer MOSs. The analyst can also determine maintainer manpower requirements for deployment and retirement schedules.

The analyst determines operator manpower requirements for the Predecessor and Proposed Systems only. He or she uses mission-event task timelines to estimate operator workload and then assigns this workload to the operator MOS. The analyst can also determine operator manpower requirements for deployment and retirement schedules.

In the final substep the analyst determines standard-position, supervisory, and policy-driven manpower requirements. The analyst determines supervisors based on the number of direct maintainers the system requires. He or she uses AR 570-2, *Manpower Requirements Criteria (MARC) — Tables of Organization and Equipment*, to determine standard positions, and uses Army doctrine to determine policy-driven requirements.

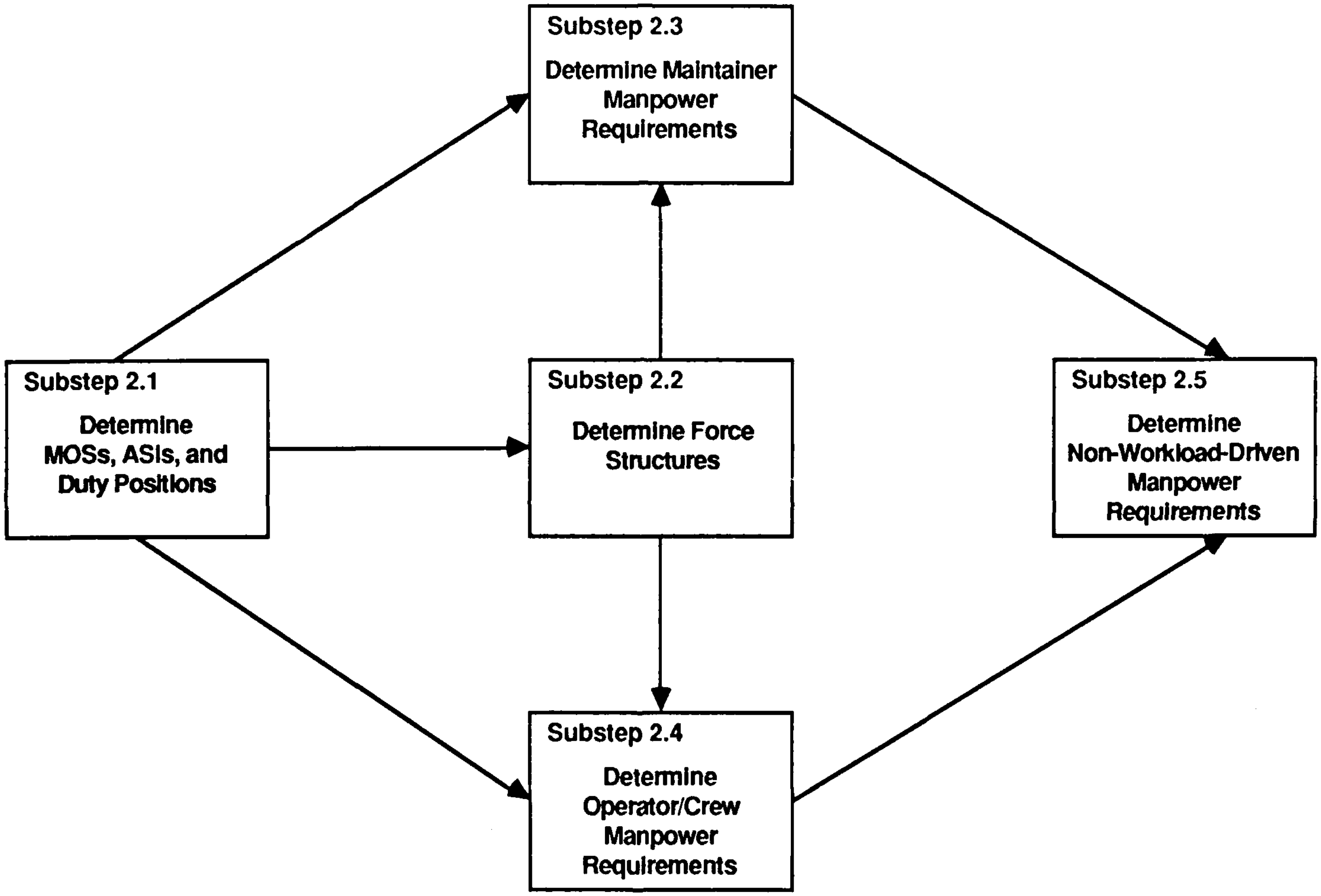


Figure 2-1. Overview of Step 2, Manpower Requirements Analysis.

Substep 2.1: Determine MOSs, ASIs, and Duty Positions

Overview

In this substep the analyst identifies the Military Occupational Specialties (MOSs), Additional Skill Identifiers (ASIs), and duty positions of the soldiers who will operate and maintain the New System. Figure 2.1-1 is an overview of this substep.

The analyst identifies the operator MOS, ASIs, and duty positions for the Predecessor and Proposed Systems but not for the Baseline Comparison System (BCS). The analyst identifies maintainer MOSs and ASIs for the Predecessor System, BCS, and Proposed System.

The procedures the analyst uses to determine MOSs depend on the New System's acquisition phase. If the New System is in the late stages of its acquisition process, the Army will probably have selected the MOSs (the target audience) that will operate and maintain the New System. The analyst should use these MOSs.

If the New System is in the early stages of its acquisition process, the Army may not have selected the MOSs. The analyst uses comparability analysis to identify MOSs that perform operation and maintenance tasks similar to the operation and maintenance tasks required by the New System. These MOSs must be from an appropriate Career Management Field (CMF) and also must have skills and knowledge similar to the skills and knowledge required by the New System.

NOTE

MOSs and ASIs should be approved by the Technical Advisory Group (TAG).

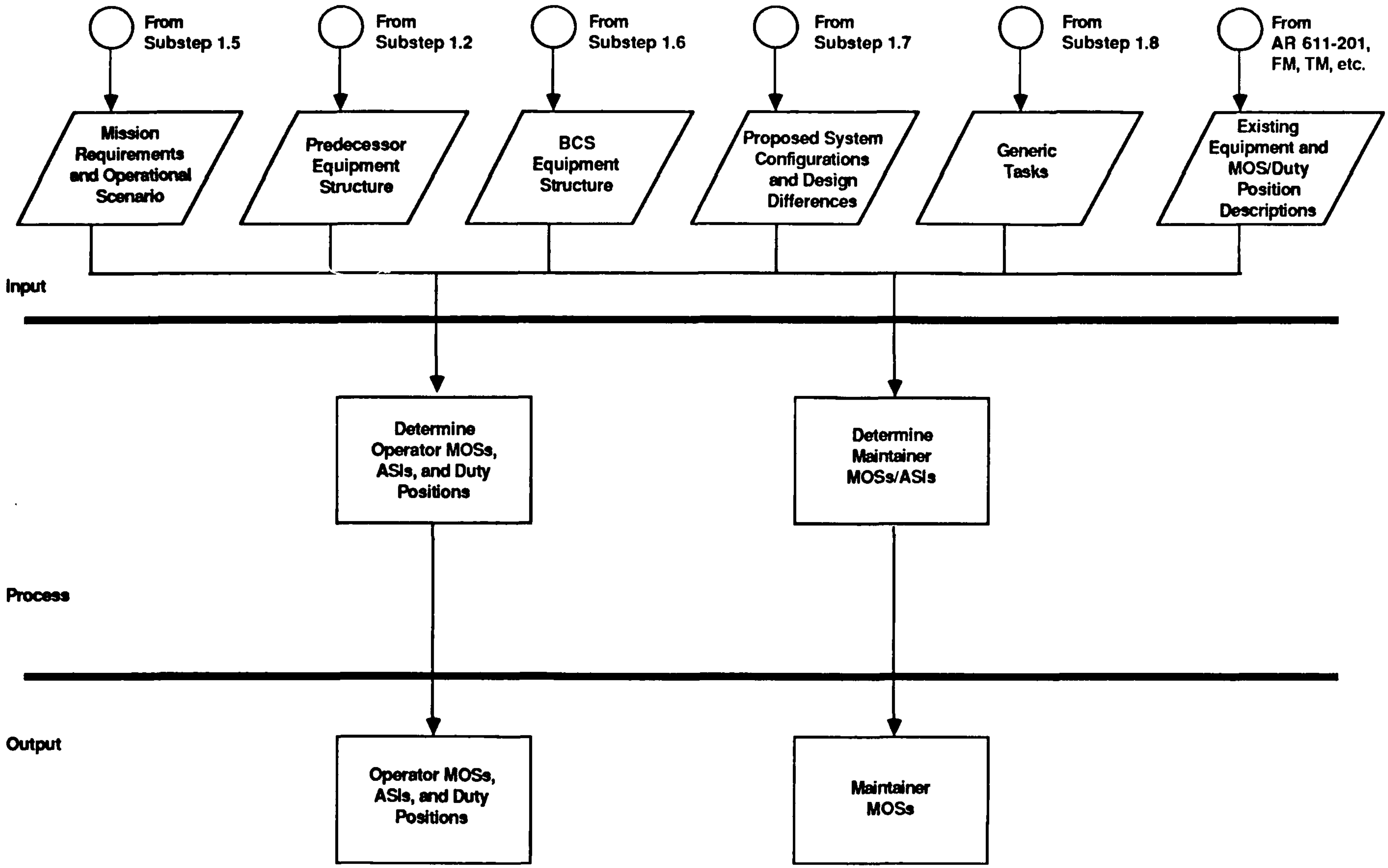


Figure 2.1-1. Overview of Substep 2.1, Determine MOSs, ASIs, and Duty Positions.

Action Step 1: Determine the Operator MOS, ASIs, and Duty Positions

Discussion

In this action step the analyst determines the operator MOS, ASIs, and duty positions for the Predecessor and Proposed Systems.

NOTE

> Operators are not identified for the BCS because the BCS is a composite of fielded equipment. The analyst can use this equipment to derive reliability and maintainability (R&M) data. The BCS configuration, however, does not reflect the subsystem integration needed to simulate an operator's environment. Estimates of BCS operator requirements would therefore be a futile activity.

Usually, operator MOSs are system-specific. If the Army has not determined an operator MOS for the New System, the analyst should assume that the New System will require a system-specific MOS. The analyst should create a notional MOS and then identify an existing MOS that operates or maintains a similar or comparable system. This "comparable" MOS becomes the base on which the analyst will develop the notional MOS.

If the Army has selected the New System's operator MOS, the analyst must use that MOS. Later, in Step 5 (Impact Analysis), the HCM analysis results will indicate the positive or negative impact of this MOS decision. If necessary, the analyst can then suggest an alternative MOS that might be more appropriate.

NOTE

> The MOS, ASI, and duty position decisions the analyst makes in this action step are preliminary and may be modified during the analysis.

Procedures

1. **Identify the Predecessor System's Operator MOS, ASIs, and Duty Positions.**
   - Obtain the Predecessor System's operator MOS, ASIs, and duty positions from the Table of Organization and Equipment (TOE); Modified Table of Organization and

Equipment (MTOE); system documentation; proponent school; or AR 611-201, *Enlisted Career Management Fields and Military Occupational Specialties.*

- Record the Predecessor System operator MOS, ASIs, and duty positions on Worksheet 2.1-1.

NOTE

The analyst does not list operator tasks for the Predecessor System.

2. **Identify the Proposed System's Operator MOS, ASIs, and Duty Positions.**

   - Record on Worksheet 2.1-1 the operator tasks identified in Substep 1.8.
   - Extract the Proposed System's operator MOS, ASIs, and duty positions from the Qualitative and Quantitative Personnel Requirements Information (QQPRI) or other sources.
   - Determine which operator tasks are performed by each MOS, ASI, and duty position.
   - Record the MOS, ASIs, and duty positions on Worksheet 2.1-1.
   - If a QQPRI does not exist or does not list the operator MOS, identify a notional MOS.

NOTE

The MOS code and MOS title selected for this notional operator MOS should be similar to an MOS within the CMF. The notional MOS is for the HCM analysis only. The Army will determine the actual MOS code and title.

   - Identify a comparable operator MOS by locating the CMF in AR 611-201 that lists the New System's functional branch operator MOSs.
   - Select an MOS that is capable of performing the New System's generic operator tasks (Substep 1.8) by comparing these tasks with the MOS descriptions in AR 611-201, the trainer's guide, soldier's manual, and technical manuals.

- Use the existing MOS's duty positions, if they are appropriate, or create new duty positions.
- Determine whether the comparable MOS can perform the New System's operator tasks. If any of these tasks are not currently performed by the comparable MOS, identify another MOS, Air Force Specialty Code (AFSC), or Navy Rating that does perform the task. The training analyst will use the training from this MOS, AFSC, or Navy Rating to determine the operator MOS's training requirements.
- Record the Proposed System's operator MOS, ASIs, and duty positions on Worksheet 2.1-1.

Procedure 1 Example

The analyst uses the TOE, MTOE, and AR 611-201 to determine the Predecessor System's operator MOS, ASIs, and duty positions. The Predecessor System is the M1 ABRAMS tank.

MOS	ASI	Duty Positions
19K-M1 Armor Crewman	None	Loader Driver Gunner Commander

(Tank commanders can be officers, but officers are beyond the HCM's scope.)

Procedure 2 Example

The analyst determines that the New System will require a system-specific operator MOS. The analyst creates a notional MOS (19XX) and assigns the operator tasks to this MOS. The new tank will have only a three-man crew. The analyst therefore assigns tasks to only three duty positions rather than the existing four duty positions in the 19K. (The loader duty position is eliminated because the tank will have an autoloader.)

Action Step 2: Determine Maintainer MOSs/ASIs

Discussion

In this action step the analyst determines maintainer MOSs/ASIs for the Predecessor System, BCS, and Proposed System. The analyst makes these determinations by comparing the New System's equipment and maintenance tasks with existing MOSs/ASIs and equipment.

Procedures

1. **Identify the Predecessor System's Maintainer MOSs/ASIs.**
   - Use the Predecessor System's equipment list to identify components that have Line Item Numbers (LINs).
   - Search the Manpower Requirements Criteria (MARC) data base for each LIN.
   - If the LIN is in the data base, record its MOSs/ASIs and their maintenance levels on Worksheet 2.1-2.
   - If the LIN is not in the data base, look at adjacent LINs and note whether these pieces of equipment are similar to the equipment being researched. If there are no similar LINs in the data base, search the equipment nomenclatures for similar equipment.
   - If more than one MOS/ASI is indicated at each maintenance level, consult AR 611-201 for each MOS listed. From the description provided, determine the equipment that each MOS maintains at that maintenance level.
   - Record on Worksheet 2.1-2 the MOS responsible for each piece of equipment at each maintenance level.
   - If the LIN is listed several times with multiple MOSs/ASIs, obtain the TOEs identified in Substep 1.2 and determine which MOSs are found in the maintenance units that support the New System.
   - Record the MOSs at their appropriate maintenance level on Worksheet 2.1-2.

NOTE

All MOSs/ASIs identified in this action step should be compared with the MOS descriptions in AR 611-201 and verified by subject-matter experts (SMEs) from each proponent school. Proponents for individual MOSs are listed in AR 600-3, *The Army Specialty Proponent System* and DA Pam 351-9, *EPMS Master Training Plan*. Proponents for system equipment are found in TRADOC Cir 351-1, *Common Job and Task Management*.

2. **Identify BCS and Proposed System Maintainer MOSs/ASIs.**

- Extract maintainer MOSs/ASIs from the New System's QQPRI and other sources.

NOTE

The analyst must be cautious with QQPRI MOSs because the Army proponent schools may not have reviewed these MOSs and because they may reflect only the MOSs in the MARC data base at that time.

- If a QQPRI does not exist or does not list maintainer MOSs/ASIs, use the MARC data base to identify the MOSs that maintain the existing equipment.
- Locate in the MARC data base those pieces of BCS and Proposed System equipment that are Government Furnished Equipment (GFE), product-improved equipment, or new equipment that is a close derivative of existing equipment.
- If the new equipment is significantly different from existing equipment, identify an MOS that can maintain the equipment by locating the CMF in which similar maintenance tasks on similar equipment are performed.
- Compare the new equipment's generic maintenance tasks (Substep 1.8) with the MOS descriptions in AR 611-201 and with and with MOS-specific Programs of Instruction (POIs).
- Select an MOS that can maintain the new equipment based on skills and knowledge, maintenance level, and job similarity. If an MOS cannot be identified that performs all the required maintenance, look for another MOS, AFSC, or

Navy Rating that does perform the necessary maintenance. The training analyst will use the training from this MOS, AFSC, or Navy Rating to determine the maintainer MOS's training requirements.

- Assign the new equipment's maintenance to an existing MOS, or, if necessary, create a notional MOS to indicate that a new MOS may be required.

NOTE

The analyst may find the *Occupational Conversion Manual* helpful when using comparable equipment from other services. This manual cross-references Navy, Air Force, Marine Corps, and Army occupations. *The Dictionary of Occupational Titles* may be helpful in cross-referencing military and civilian jobs.

- Record the MOSs and ASIs by maintenance level on Worksheet 2.1-2.

Procedure 1 Example

The analyst determines the Predecessor System's maintainer MOSs and ASIs by searching the MARC data base for each LIN associated with the Predecessor System. The Predecessor System is the M1 ABRAMS Tank, LIN T13374. The MOSs below are a partial listing of the Predecessor System's MOSs.

MOS/ASI	MOS Title	Maintenance Level
31V	TAC Comm Sys Op/Mech	ORG
45E	M1 ABRAMS Turret Mech	ORG
45GL8	Fire Control Sys Rep	DS
45KL8	Tank Turret Rep	DS
63E	M1 ABRAMS Tank Sys Mech	ORG
63GL8	Fuel & Elec Sys Rep	DS/GS
63HL8	Track Vehicle Rep	DS/GS

Procedure 2 Example

The analyst finds the following MOSs and ASIs listed in the QQPRI: 31V, 45E, 45GL8, 45KL8, and 63HL8. The analyst determines that 63E, M1 ABRAMS Tank System Mechanic, maintains a gas turbine engine. The New System will have a diesel engine. The analyst studies the other MOSs in CMF 63 and identifies a diesel engine repairer, the 63N, M60A1/A3 Tank System Mechanic. The analyst has several options available in this situation. If the Army has determined that the New System will not create any new MOSs and has selected the 63E as the new tank's system repairer, the analyst must use the 63E. The analyst should, however, point out any increased training burden or other consequences that this choice might have because the 63E would then have to be trained to maintain two engines.

The analyst could also select the 63N as the new tank's system repairer and add the 63E's training. This decision is probably not the best choice because the 63N maintains an older tank with different training.

If the Army has not chosen an MOS, the analyst may decide to create a notional MOS that is a composite of the 63E and the 63N: MOS 63XX.

When deciding which MOS selection option to use, the analyst must use his or her judgment and must seek the advice of the Technical Advisory Group (TAG). He or she must also document all decisions and recommendations concerning MOS selection.

SUBSTEP 2.1
WORKSHEETS

WORKSHEET 2.1-1

Use this worksheet to document the operator MOSs, ASIs, and duty positions.

Configuration: Predecessor Proposed

New System Operator Tasks	Operator MOSs/ASIs	Duty Positions

WORKSHEET 2.1-2

Use this worksheet to document the maintainer MOSs and ASIs.

Configuration: Predecessor Proposed

Equipment Number	Equipment Name	Line Item Number	Generic Tasks	Maintenance Level	Maintainer MOSs/ASIs

Substep 2.2: Determine Force Structures

Overview

In this substep the analyst uses Army documents to develop force structures and distribute the New System within these force structures. The documents include the Operational and Organizational (O&O) Plan; Materiel Fielding Plans (MFPs); Required Operational Capability (ROC); Basis of Issue Plan (BOIP); Draft Table of Organization and Equipment (DTOE); and Army Modernization Information Memorandum (AMIM). Figure 2.2-1 is an overview of this substep.

A force structure includes the number and type of units that will receive the New System. The number of force structures the analyst must determine depends on the scope of the HCM analysis. The analyst will always develop a steady-state, Active Army force structure for the Predecessor, Baseline Comparison, and Proposed Systems. The number of force structures required will increase as the scope of the analysis expands. If the HCM analysis includes the Reserve Components (ARNG and USAR), the analyst must develop force structures for each of these Army components. The scope of the analysis may also require the analyst to develop force structures to account for deployment and retirement schedules. Figure 2.2-2 depicts the steady-state and deployment/retirement phases of system fielding.

NOTE

Force structures and system densities should be approved by the Technical Advisory Group (TAG).

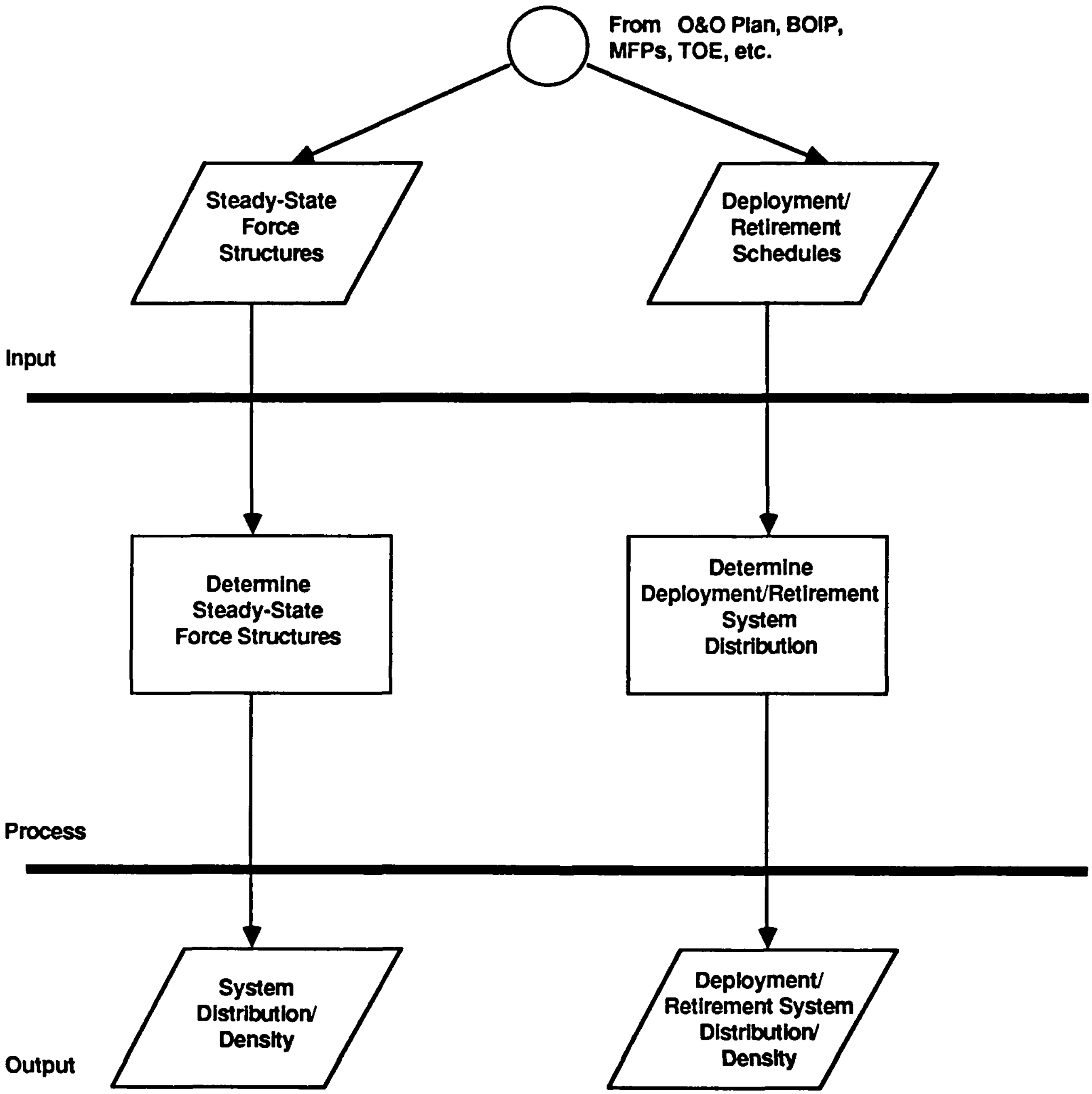


Figure 2.2-1. Overview of Substep 2.2, Determine Force Structures.

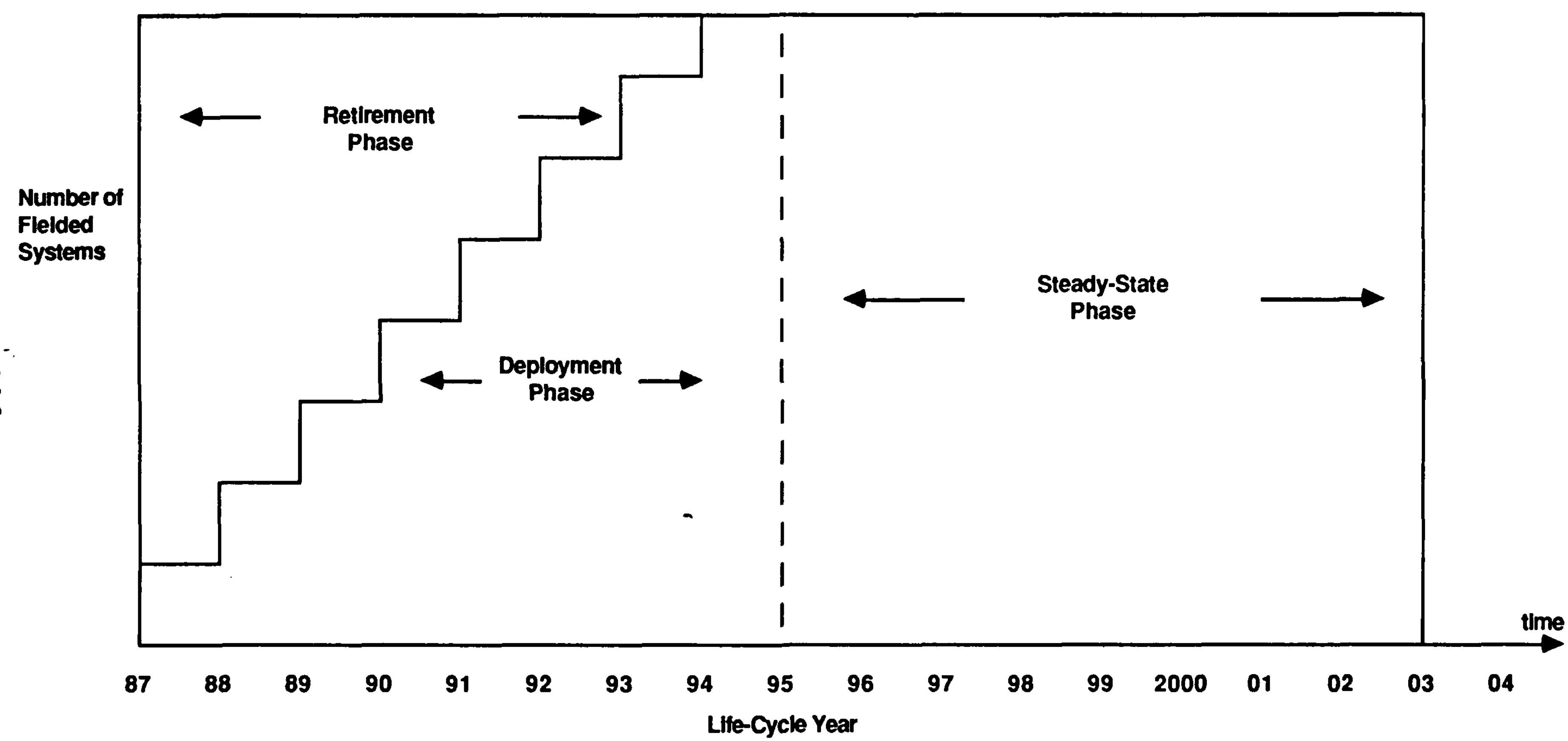


Figure 2.2-2. System-fielding phases.

Action Step 1: Determine Steady-State Force Structures

Discussion

The analyst uses the procedures in this action step to develop steady-state force structures for the Predecessor, Baseline Comparison, and Proposed Systems. The analyst must develop a force structure for each Army component (Active, Reserve, National Guard) within the analysis scope. Force structures include the number of systems (system density) and the units that will receive them.

The best way to develop a force structure is to determine the units that will receive the New System, how many units of that type exist, and how many systems these units will receive. If Army documents and subject-matter experts (SMEs) do not provide this detailed information, the analyst can use the number of systems to be fielded in a "typical" Section to develop a simple force structure (Procedure 3 of this action step). The analyst can use this Section's system density to determine a typical force structure at any level he or she desires.

Procedures

1. **Obtain the Total System Density.**
   - Use the New System documents to determine the total number of systems to be fielded in each Army component.
   - Record the total system density on Worksheet 2.2-1.

NOTE

The number of systems to be fielded represents only the systems supplied to TOE units. Additional systems assigned to Prepositioned Materiel Configured to Unit Sets (POMCUS), Table of Distribution and Allowances (TDA) Units, and operationally ready floats (ORF) are outside the HCM's scope.

The Army's best estimate of system density may change frequently. Review any inconsistencies in the New System documents with the appropriate program office personnel.

2. **Develop Force Structures.**

- Use applicable source documents and The Army Authorization Documents System (TAADS) Header Listing to develop force structures for the Predecessor, Baseline Comparison, and Proposed Systems. Begin the force structures at the lowest level of indenture, for example, squad/section/platoon. Build successive echelons from this base.
- Determine a system density for each unit in the force structure.
- Identify each unit's maintenance responsibility.
- Record the force structures on Worksheet 2.2-1.

3. **Calculate System Densities.**

- Determine the system density per Company/Battery by multiplying the system density per Section by the applicable number of Sections in a Company/Battery.

$$\frac{\text{SD}}{\text{Section}} \times \frac{\text{Sections}}{\text{Company}} = \frac{\text{SD}}{\text{Company}}$$

Where:

SD = System Density

- Determine the system density per Battalion by multiplying the system density per Company by the number of Companies per Battalion.

$$\frac{\text{SD}}{\text{Company}} \times \frac{\text{Companies}}{\text{Battalion}} = \frac{\text{SD}}{\text{Battalion}}$$

- Continue these calculations until the desired level of the force structure has been reached.
- Record each unit's system density and maintenance responsibility on Worksheet 2.2-1.

Procedure 1 Example

The analyst determines the total system density for each Army component being studied:

Weapon System: Helicopter
Active Army: 1.983
USAR/ARNG: 1.257

Procedure 2 Example

The analyst must develop a force structure for each Army component being studied. This example is a part of the Active Army force structure for a helicopter.

Units	Unit Density	System Density	Maintenance Level
Active Army	1		
2nd Infantry Division (ID)	1	82	AVIM
Attack Battalion (BN) 2nd	1	34	AVUM
Command Aviation Company (AVN CO)	1	18	AVUM
Reconnaissance (Recon) BN 2nd	1	30	AVUM
ID Light	4	60	AVIM
Attack BN Light	1	34	AVUM
Headquarters and Headquarters Troop (HHT) Light	1	6	AVUM
Recon BN Light	1	20	AVUM
Regimental Combat		3	AVIM
Aviation Squadron (RCAS)	3	53	AVIM
Attack Troop (TRP)	2	11	AVUM
HHT RCAS	1	1	AVUM
Recon TRP RCAS	3	10	AVUM
Separate Brigade	7	5	AVIM
Brigade HQ	1	5	AVUM
XVIII Corps	1	142	AVIM
Attack Regiment (REG) XVIII	1	39	AVUM
CAB/AVN Group (GRP)	1	63	AVUM
Recon Squadron (SQDN) XVIII	1	40	AVUM

(continued)

Procedure 2 Example (continued)

Units	Unit Density	System Density	Maintenance Level
I Corps	1	2	AVIM
CAB/AVN GRP	1	2	AVUM
ID Heavy I	6	51	AVIM
Attack BN Heavy I	1	13	AVUM
CAC Heavy I	1	18	AVUM
CAV SQDN Heavy I	1	20	AVUM
ID Heavy II	4	64	AVIM
Attack BN Heavy II	2	13	AVUM
Heavy II	1	18	AVUM
CAV SQDN Heavy II	1	20	AVUM

Procedure 3 Examples

A. A Division command and control system consists of seven pieces of equipment. Different combinations of this equipment are distributed to each Section. Given the following information, the analyst can determine the density of each piece of equipment in each Section (Table 2.2-1).

B. A field artillery Battery contains six firing Sections. Each Section has one self-propelled howitzer (SPH). A field artillery Battalion contains three Batteries. and Division artillery consists of three Battalions.

The analyst obtains the following results for system densities at each level:

Battery:

$$\frac{1\ \text{SPH}}{\text{Section}} \times \frac{6\ \text{Sections}}{\text{Battery}} = \frac{6\ \text{SPH}}{\text{Battery}}$$

Battalion (Organizational Maintenance):

$$\frac{6\ \text{SPH}}{\text{Battery}} \times \frac{3\ \text{Batteries}}{\text{Battalion}} = \frac{18\ \text{SPH}}{\text{Battalion}}$$

Division (Direct Support Maintenance):

$$\frac{18\ \text{SPH}}{\text{Battalion}} \times \frac{3\ \text{Battalions}}{\text{Division}} = \frac{54\ \text{SPH}}{\text{Division}}$$

(continued)

Table 2.2-1. Equipment Density by Section and Division

Density By Section:

Equipment	Section 1	2	3	4	5	6	7	8
Large-Screen Display	2	1						1
Input/Output Display	2	1	1	1				1
Keyboard	2	1	1	1				1
Printer	1	1		1				1
Microprocessor			1					
CPU	2	1		1			2	1
Hand-held Interactive Display					4	3		
Number of Sections per Division:	1	1	3	3	6	32	2	1

Density By Division:

Equipment	Division 1	2	3	4	5	6	7	8	Density
Large-Screen Display	2	1						1	4
Input/Output Display	2	1	3	3				1	10
Keyboard	2	1	3	3				1	10
Printer	1	1		3				1	6
Microprocessor			3						3
CPU	2	1		3			4	1	11
Hand-held Interactive Display					24	96			120
									164

Action Step 2: Determine Deployment/Retirement System Distribution

Discussion

In this action step the analyst determines force structures based on deployment and retirement schedules. The Deputy Chief of Staff for Operations and Plans (DCSOPS) develops a system-fielding plan that specifies the New System's deployment schedule. The analyst can use this schedule to determine the coinciding retirement schedule. The Predecessor System is retired when the New System and the unit to which it is deployed are operationally ready, normally within 90 days.

The deployment schedule is usually reported by quarter over the number of years required to complete New System deployment. The analyst determines manpower requirements for each time interval within the deployment schedule.

NOTE

The analyst performs this action step only if the determination of deployment/retirement manpower requirements is within the analysis scope.

Procedures

1. **Determine the Deployment Distribution.**

   - Determine the number of systems to be fielded per time period, the number and type of units scheduled to receive the system per time period, and the system densities for each unit.

   - Plot this information on a timeline representing the deployment schedule on Worksheet 2.2-2.

2. **Determine the Retirement Distribution.**

   - Determine the New System's operational readiness date and designate that date as the Predecessor System's retirement date.

   - Plot the Predecessor System's retirement schedule on a timeline below the New System deployment schedule on Worksheet 2.2-2.

Procedure 1 and 2 Examples

The analyst determines the deployment and retirement schedules as shown on the following page. The analyst determines that the New System will be operationally ready 90 days after unit fielding. The Predecessor System is then retired.

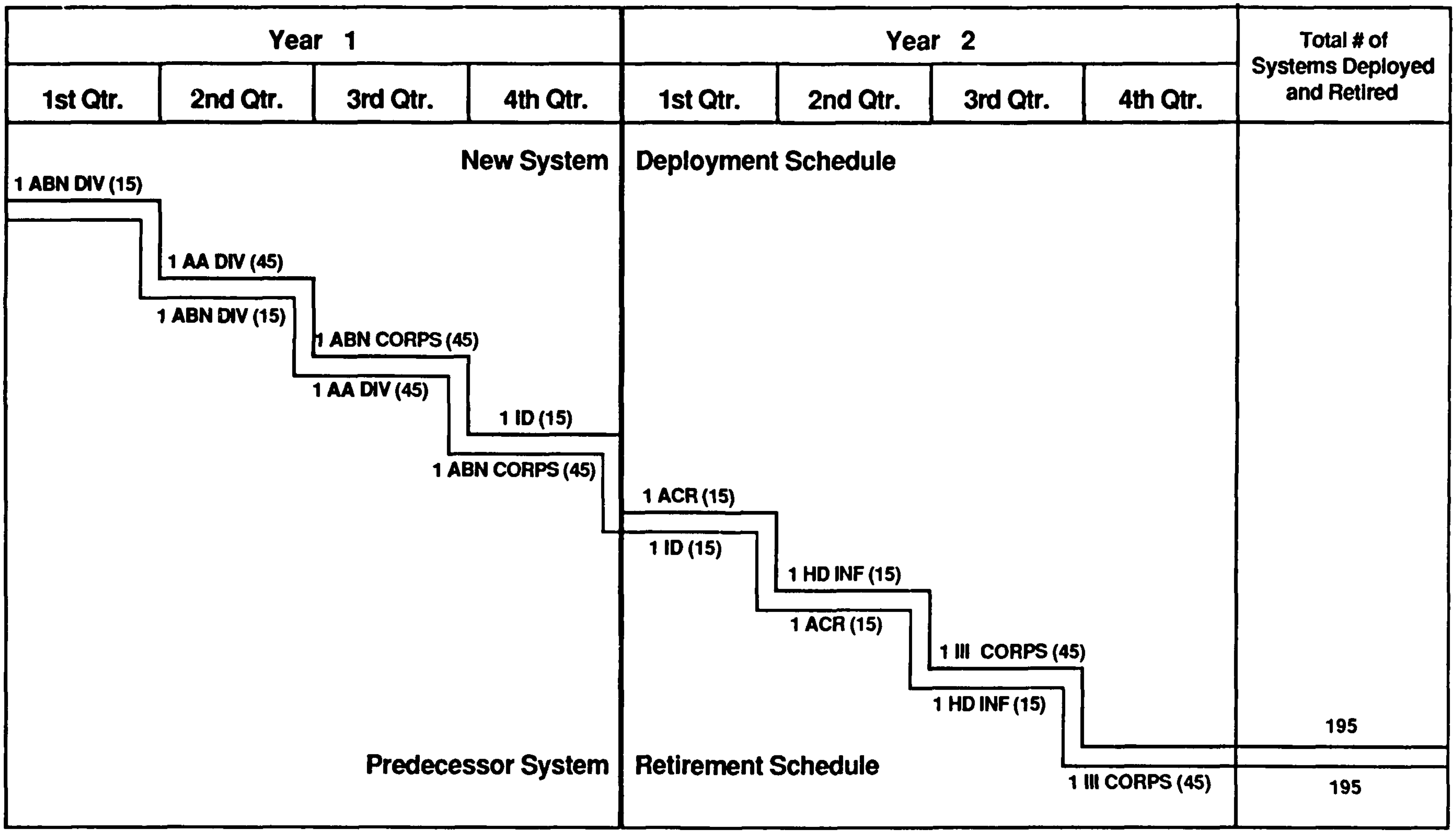


Figure 2.2-3. Sample deployment/retirement schedules.

SUBSTEP 2.2
WORKSHEETS

WORKSHEET 2.2-1

Use this worksheet to document the New System's force structure.

Army Component: Active Reserve National Guard

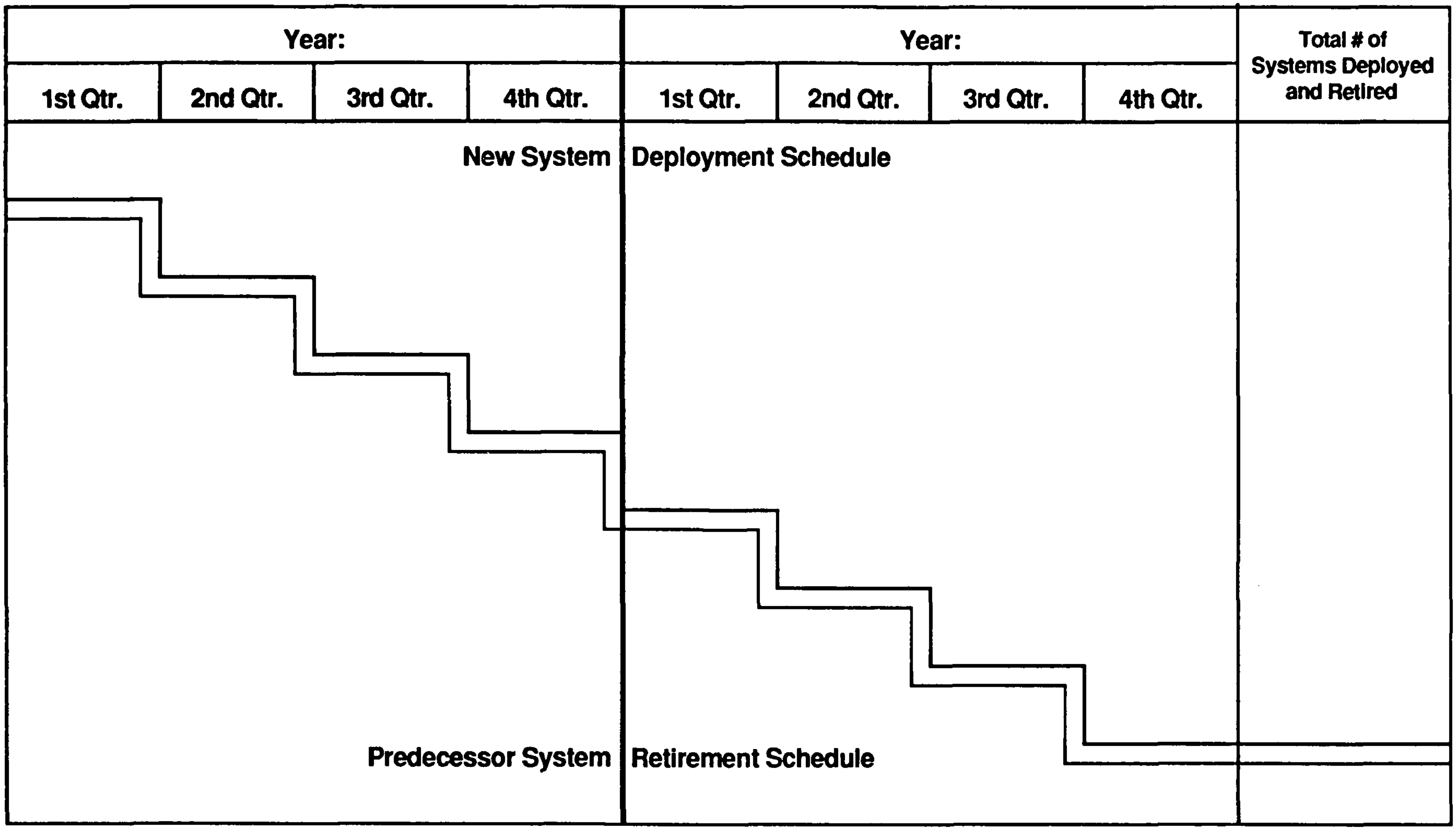
Configuration: Predecessor BCS Proposed

Total System Density: ___________

Unit Name	Number of Units	System Density	Maintenance Level

WORKSHEET 2.2-2

Use this worksheet to plot the deployment and retirement schedules.



Substep 2.3: Determine Maintainer Manpower Requirements

Overview

In this substep the analyst determines maintainer manpower requirements for the Predecessor System, Baseline Comparison System (BCS), and Proposed System. The analyst uses maintenance workload, Available Productive Man-Hours (APMH), and system densities (Substep 2.2) to calculate these maintainer requirements. Figure 2.3-1 is an overview of this substep.

The analyst can use three methods to determine the Predecessor System's manpower requirements. The method the analyst applies should have been determined when the HCM Analysis Plan was developed. The most extensive method in terms of time and resources is an analysis of the Predecessor System's fielded reliability and maintainability (R&M) data. In the second method the analyst uses the Manpower Requirements Criteria (MARC) data base to identify Predecessor System workload. In the third method the analyst uses the Tables of Organization and Equipment (TOEs), which provide the manpower assigned to each unit with a Predecessor System.

The analyst determines BCS manpower requirements by using fielded R&M data to identify maintenance workload. He or she uses estimated R&M data to determine maintenance workload for the Proposed System.

The analyst determines maintenance workload using the maintenance ratios developed by the engineering analyst in Substep 1.9. After he or she determines the maintenance workload, the analyst must meet with the training analyst to update the MOS and paygrade selections made in Substep 2.1. The analyst then determines APMH and calculates the maintainer manpower requirements. Action Step 6 includes procedures for determining manpower requirements during system deployment and retirement. The analyst applies these procedures only if the analysis scope includes the calculation of deployment and retirement manpower requirements. The last action step includes procedures for determining combat damage manpower requirements. These procedures are only applied when a combat damage workload assessment is within the analysis scope.

NOTE

> In this substep the analyst determines crew maintenance workload and assigns it to the appropriate MOSs; however, he or she does not develop crew maintenance manpower requirements. The crew maintenance workload is added to the operator workload in Substep 2.4, Action Step 4.

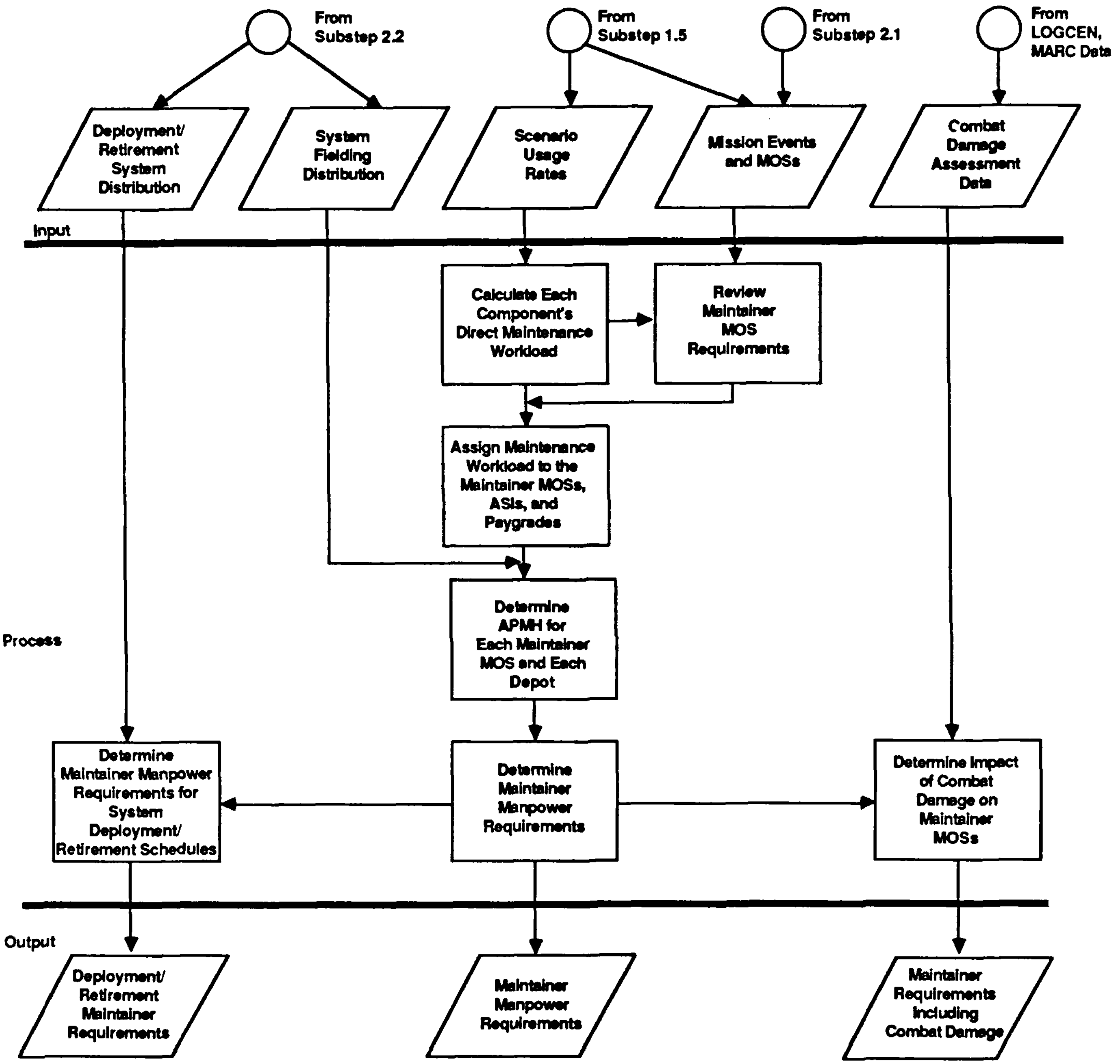


Figure 2.3-1. Overview of Substep 2.3, Determine Maintainer Manpower Requirements.

Action Step 1: Calculate Each Component's Direct Maintenance Workload

Discussion

In this action step the analyst calculates maintenance workload for each component in the Predecessor System, BCS, and Proposed System configurations. The analyst uses maintenance ratios (MRs) and scenario usage rates to determine this workload.

If the New System has multiple usage rates, the analyst must determine which usage rate is appropriate for each piece of equipment. For example, the analyst would apply a "miles driven" usage rate to those pieces of equipment that are effected by the miles traveled. The analyst would apply a "rounds fired" usage rate to any gun or cannon on the system.

Procedures

1. **Review Maintainer Workload Data.**
   - Obtain the equipment list for the Predecessor, Baseline Comparison, and Proposed Systems.
   - Obtain each component's MRs by maintenance level from Substep 1.9.
   - Be certain that each component's MRs represent direct maintenance only. Some maintenance reporting systems (Navy 3M, for example) include indirect workload time.
   - Ensure that all associated maintenance tasks were considered in the MR calculations.
   - If any tasks associated with maintenance of a particular component have been excluded, adjust the MR to reflect additional required maintenance time. Coordinate these adjustments with the engineering analyst.
   - Obtain the scenario usage rate(s) from Substep 1.5 and assign a usage rate to each piece of equipment.
   - Record the equipment list, MRs, and scenario usage rate(s) on Worksheet 2.3-1.
2. **Calculate Direct Maintenance Workload.**
   - Use the following formula to calculate the maintenance workload for each component at each maintenance level:

$$DW = UR \times MR$$

Where:

DW = Direct Workload
UR = Scenario Usage Rate
MR = Maintenance Ratio

- Record the direct workload on Worksheet 2.3-1.

Procedure 1 Example

The analyst reviews a helicopter system's BCS equipment. He or she then obtains each component's MRs from Substep 1.9 and the component's scenario usage rate from Substep 1.5.

Equipment Name	Maintenance Ratios AVUM	AVIM	DEPOT	Scenario Usage Rate
Pressurized Air System	.0343	.1029	.0611	240 Flight Hours per Year
30mm-Gun	.0041	.0098	.0101	20,000 Rounds per Year

Procedure 2 Example

The analyst calculates each maintenance level's workload, which is expressed in maintenance man-hours (MMH).

Equipment Name: Pressurized Air System

AVUM = 240 x 0.0343 = 8.23 MMH/Year

AVIM = 240 x 0.1029 = 24.70 MMH/Year

Depot = 240 x 0.0611 = 14.66 MMH/Year

Action Step 2: Review Maintainer MOS Requirements

Discussion

In this action step the manpower analyst must meet with the engineering and training analysts to make final maintainer MOS and ASI selections for the BCS and Proposed System. The analysts must also determine each maintainer's skill level and paygrade.

The training analyst used the initial MOS and ASI selections during the training task analysis. In this action step the manpower and training analysts must compare each MOS's workload and training tasks. The workload task list may include tasks that the training analyst did not include in the training task list and vice versa. The analysts must determine whether both task lists include every task that must be performed and trained. Task descriptions on both lists should have consistent terminology. During this process the analysts should pay particular attention to discrepancies between the workload task's paygrade and the skill level at which the task is trained. Such discrepancies indicate that a task is being performed in the field at one skill level but is being trained at a different skill level.

Procedures

1. **Compare the Maintenance Workload Tasks with the Training Tasks and Determine Paygrades.**
   - List on Worksheet 2.3-2 each maintenance workload task and its paygrade as provided by the R&M data source.
   - List on Worksheet 2.3-2 each training task and its skill level as provided by the training data source.
   - Determine whether the workload tasks are reflected in the training tasks. Reconcile any differences and update both task lists accordingly.
   - Update the MOS and ASI selections if necessary and record the MOSs and ASIs on Worksheet 2.3-3.
   - Evaluate the paygrade of each maintenance workload task and the skill level of each training task.
   - Determine whether the New System requires changes to the maintainer MOSs' paygrades or skill levels.
   - Record each MOS's paygrade on Worksheet 2.3-3.

2. **Update the Description of Each Maintainer MOS in the Revised Target Audience Description (TAD).**

   - If changes to an existing MOS are necessary, update the Revised MOS Description Form in Substep 3.1.

Procedure 1 & 2 Examples

The example in Action Step 2 of Substep 2.1 is continued here. The New System is a replacement for the M1 ABRAMS tank. The manpower analyst determined in Substep 2.1 that the following maintainer MOSs are required to maintain the New System:

MOS/ASI	MOS Title	Maintenance Level
31V	TAC Comm Sys Op/Mech	ORG
45E	M1 ABRAMS Turret Mech	ORG
45GL8	Fire Control Sys Rep	DS
45KL8	Tank Turret Rep	DS
63HL8	Track Vehicle Rep	ORG/DS
63XX	Diesel Engine Mech	ORG

The manpower, training, and engineering analysts convene and determine that the existing MOSs that were chosen are appropriate. The notional MOS, 63XX, is discussed in detail, and the decision to create this MOS is upheld. These decisions are based on a careful review of the workload tasks and training tasks.

The manpower and training analysts evaluate the paygrade assignments given by the R&M data source and the training-source index and make any required adjustments. The analysts then review each MOS's description in the Revised TAD and develop a description for 63XX.

Action Step 3: Assign Maintenance Workload to the Maintainer MOSs, ASIs, and Paygrades

Discussion

In this action step the analyst determines which maintainer MOSs, ASIs, and paygrades will perform each component's maintenance workload at each maintenance level.

NOTE

Depot maintainers are not identified by an MOS or skill level. Depot maintenance workload, therefore, is not reported by MOS; it is reported by Total Maintenance Man-Hours (TMMH) for each component group (e.g., airframe, electrical, avionics, hydraulics, engine, drivetrain, etc.).

Procedures

1. **Assign Direct Maintenance Workload to an Appropriate MOS, ASI, and Paygrade.**

   - Using the information on Worksheets 2.3-1 and 2.3-3, determine the MOS, ASI, and paygrade that maintains each component at each maintenance level. Base this judgment on knowledge of the maintainer MOSs and each component's required maintenance tasks.

   - Record the following selections on Worksheet 2.3-4:

     - MOS/ASI
     - Paygrade
     - Equipment
     - Maintenance Level
     - Direct Workload

1a. **Assign Direct Maintenance Workload to the Appropriate Depot.**

   - Base these workload assignment decisions on knowledge of the type of work each depot performs (Table 2.3-1). If a new component or maintenance requirement cannot easily be assigned to a depot, consult Army personnel to determine the appropriate depot.

   - Record the depot selections on Worksheet 2.3-4.

Table 2.3-1. Major Depot Missions

- ANNISTON ARMY DEPOT (ANAD)
  Heavy Combat Vehicles
  Anti-Tank Missiles
  Small Arms Weapons
- CORPUS CHRISTI ARMY DEPOT (CCAD)
  Helicopters
  Aircraft Engines/Transmissions
- LETTERKENNY ARMY DEPOT (LEAD)
  Air Defense Missiles
  Self-propelled and Towed Artillery
  Fire Control Not Associated with End Items
- MAINZ ARMY DEPOT (MAAD)
  Heavy Combat Vehicles
  Light Combat Vehicles
  Missiles
- RED RIVER ARMY DEPOT (RRAD)
  Light Combat Vehicles
  Air Defense Missiles
  Combat Rubber Products
- SACRAMENTO ARMY DEPOT (SAAD)
  Strategic Electronics
  Night Vision Equipment
- TOBYHANNA ARMY DEPOT (TOAD)
  Tactical Electronics
  Cameras/Projectors
  Autodin Support
- TOOELE ARMY DEPOT (TEAD)
  Automotive Vehicles
  General Equipment
  Rail and Construction Items
  Automotice Rubber Products

Procedure 1 Example

The analyst assigns the following workload at AVUM and AVIM to MOS 68J (Aircraft Fire Control Repairer).

Equipment Number	Equipment Name	Direct Workload MMH/Year	
		AVUM	AVIM
301	Armament Control	1.22	.84
302	Aerial Rocket Subsystem	23.62	16.33
311	Fire Control Computer	29.54	20.42
312	Air Data Subsystem	90.03	62.23
313	Fire Control Interface	10.98	7.59
		155.39	107.41

Procedure 1a Example

The analyst assigns the following workload to the Red River Army Depot:

Equipment Number	Equipment Name	Direct Workload MMH/Year
301	Armament Control	5.81
302	Aerial Rocket Subsystem	97.84
311	Fire Control Computer	50.87
312	Air Data Subsystem	110.05
313	Fire Control Interface	5.38

Action Step 4: Determine Available Productive Man-Hours for Each Maintainer MOS and Each Depot

Discussion

In this action step the analyst determines Available Productive Man-Hours (APMH) for each maintainer MOS and each depot. The analyst's principal sources of information are Army Regulation 570-2, *Manpower Requirements Criteria (MARC) — Tables of Organization and Equipment*, and the Depot Systems Command (DESCOM). AR 570-2 and DESCOM provide Annual Available Productive Man-Hours (AAPMH). In this action step the analyst must determine whether an AAPMH is appropriate depending on the time period used to determine workload.

NOTE

The analyst does not determine crew MOS APMH in this substep.

Chapter 3 of AR 570-2 contains instructions for determining AAPMH by unit. The analyst uses the maintenance level associated with each unit (from Substep 2.2) to assign the unit's AAPMH to the MOSs responsible for maintenance in the unit. The analyst obtains each depot's AAPMH from DESCOM.

Procedures

1. **Determine the AAPMH.**

   - Follow the instructions in AR 570-2, Chapter 3, for determining the AAPMH for each type of unit in each force structure.
   - Identify each unit's maintenance level.
   - Assign the unit's AAPMH to each maintainer MOS at the unit's maintenance level.

   NOTE

   After consulting subject-matter experts on the system's operational environment, the analyst may be directed to use non-standard factors to determine AAPMH. This practice is acceptable provided the methods and information are sufficiently documented to support deviation from AR 570-2.

1a. **Using Table 2.3-2, Determine Each Depot's AAPMH.**

2. **If maintenance workload was calculated (in Action Step 1) for periods shorter than a year, normalize the annual factor to those periods.**

NOTE

> When normalizing to a required unit of time, the analyst should be sure that he or she is dividing by the correct time periods. For example, a week can consist of 5 days (peace time work days) or 7 days (combat working days). Similarly, a year can be thought of as 240 work days or 3[illegible] work days. The analyst must be sure that the correct time units are used in all calculations.

- Divide the AAPMH by 365 to obtain daily man-hours.
- Multiply the daily hours by 7 to obtain weekly values (7-day combat week).
- Multiply the daily hours by 30 (30-day combat month) to obtain monthly values.
- Record each MOS's and each depot's APMH on Worksheet 2.3-5 and 2.3-6.

Table 2.3-2. Depot AAPMH by Individual Organic Depot

Organic Depot/Mission	Depot AAPMH (Man-Hours per Year)
Anniston Army Depot (ANAD) Heavy Combat Vehicles Anti-Tank Missiles Small Arms Weapons	1,749
Corpus Christi Army Depot (CCAD) Helicopters Aircraft Engines/Transmissions	1,750
Letterkenny Army Depot (LEAD) Air Defense Missiles Self-propelled and Towed Artillery Fire Control Not Associated with End Items	1,752
Mainz Army Depot (MAAD) Heavy Combat Vehicles Light Combat Vehicles Missiles	Unavailable
Red River Army Depot (RRAD) Light Combat Vehicles Air Defense Missiles Combat Rubber Products	1,746
Sacramento Army Depot (SAAD) Strategic Electronics Night Vision Equipment	1,743
Tobyhanna Army Depot (TOAD) Tactical Electronics Cameras/Projectors Autodin Support	1,750
Tooele Army Depot (TEAD) Automotive Vehicles General Equipment Rail and Construction Items Automotive Rubber Products	1,767

These AAPMH are valid as of the date of this publication. However, these values are subject to change and should be confirmed with the DESCOM.

Procedure 1 Example

The analyst uses AR 570-2 to determine AAPMH. A radar system in a combat unit (Type Unit Code 1), located at a division (Unit Location Code 1), with a one-base security requirement (Unit Security Code A), and a unit movement requirement of once in three days or less (Unit Movement Code A) yields the following organizational AAPMH:

	Section A	Section B	Maintainer Variable Workload-Driven Position	Resulting AAPMH
Org.	3.764	-365	-840	2.559

Procedure 1a Example

The analyst identifies each depot's AAPMH for an aviation system:

Corpus Christi Army Depot (CCAD) = 1,750 MH/year

Sacramento Army Depot (SAAD) = 1,743 MH/year

Procedure 2 Example

If the analyst calculated the maintenance workload for periods shorter than a year, he or she must normalize the AAPMH to those periods.

The analyst normalizes the AAPMH determined in the Procedure 1 example to days:

AAPMH = 2,559 MH/Year
Combat Days/Year = 365

$$\text{APMH} = \frac{2{,}559}{365} = 7.0 \text{ Hours/Day}$$

The analyst normalizes the depot AAPMH in the Procedure 1a example to days:

CCAD AAPMH = 1,750 MH/Year
Civilian Work Days/Year = 240

$$\text{APMH} = \frac{1{,}750}{240} = 7.3 \text{ Hours/Day}$$

Action Step 5: Determine Maintainer Manpower Requirements

Discussion

In this action step the analyst determines maintenance manpower requirements by MOS and maintenance level. The analyst uses direct workload (Action Step 1), APMH (Action Step 4), and system densities (Substep 2.2) to determine these manpower requirements.

NOTE

> The analyst does not determine crew manpower requirements in this substep. The crew maintenance workload is added to the operator workload in Substep 2.4, Action Step 4.

The analyst can calculate manpower requirements for each maintenance level and unit. If the analyst calculates manpower by unit, the units must then be added together to develop total manpower requirements.

The analyst may produce fractions when calculating maintainer manpower requirements. AR 570-2 prescribes a procedure to round fractions to the nearest whole number. The analyst must use judgment when applying this rounding rule. He or she should consider whether the MOS is "shared" by different systems at a particular maintenance level or whether the MOS is system-specific. If rounding down is required, the analyst should investigate whether the MOS would be unduly overloaded.

Procedures

1. **Determine the Maintainer Manpower Requirements.**

   - Use the following formula to determine each MOS's and each maintenance level's maintainer manpower requirements:

   $$M = \frac{DW \times SD}{APMH}$$

   Where:

   M = Manpower Requirement
   DW = Direct Workload
   SD = System Density
   APMH = Available Productive Man-Hours

   - Record the manpower requirements on Worksheet 2.3-5.

1a. **Determine Each Depot's Maintenance Manpower Requirements.**

- Use the following formula to determine these requirements:

$$DM = \frac{DW \times SD}{APMH}$$

Where:

DM = Depot Manpower Requirement
DW = Direct Workload
SD = System Density
APMH = Available Productive Man-Hours

- Record the depot manpower requirements on Worksheet 2.3-6.

Procedure 1 Example

The analyst determines the manpower requirements for MOS 68J at AVUM and AVIM using an annual APMH.

Maintenance Level	Direct Workload	System Density	AAPMH
AVUM	700	5	1,241
AVIM	420	25	1,423

Maintenance Manpower Requirements:

AVUM $\frac{700 \times 5}{1,241} = 2.82 = 3$ positions

AVIM $\frac{420 \times 25}{1,423} = 7.38 = 7$ positions

Procedure 1a Example

The analyst determines each depot's maintenance requirements.

Maintenance Level	Direct Workload	System Density	AAPMH
Depot	556	675	1,750

Maintenance Manpower Requirements:

Depot $\frac{556 \times 675}{1,750} = 214.46 = 214$ positions

Action Step 6: Determine Maintainer Manpower Requirements for System Deployment and Retirement Schedules

Discussion

In this action step the analyst determines the maintainer manpower requirements during New System deployment and Predecessor System retirement. The analyst uses direct workload, APMH, and the deployment/retirement time interval determined in Substep 2.2. The analyst also uses the deployment and retirement system densities from Substep 2.2 (instead of the steady-state system densities).

NOTE

The analyst performs this action step only if development of deployment/retirement manpower requirements is within the analysis scope.

Procedures

1. **Determine the Maintainer Manpower Requirements During New System *Deployment*.**

   - Use the following formula to calculate the maintenance manpower requirements by MOS and maintenance level for each time interval in the deployment schedule:

$$M_t = \frac{DW \times DSD_t}{APMH}$$

Where:

M_t = Manpower Requirement (At Time Interval t)

DW = Direct Workload

DSD_t = Deployment System Density (Cumulative Number of Systems at Time Interval t)

APMH = Available Productive Man-Hours

- Substitute the appropriate system densities at each time interval. System density is the only variable that will change in subsequent applications of this equation.
- Complete these calculations for each time interval and fiscal year until the New System has been fully deployed.
- Record the system deployment manpower requirements for each time interval t on Worksheet 2.3-7.

2. **Determine Maintainer Manpower Requirements During Predecessor System Retirement.**

   - Calculate each retirement time interval's maintenance manpower requirements by MOS and maintenance level. Use the following formula if the Predecessor requirements were developed from TOEs or MARC:

$$M_t = \frac{RSD_t \times \frac{TMR}{TSD}}{AMPH}$$

Where:

M_t = Manpower Requirement (At Time Interval t)

RSD_t = Retirement System Density (Remaining Number of Systems at Time Interval t)

TMR = Total MOS Requirement at Each Maintenance Level (Based on Total System Density)

TSD = Total System Density

APMH = Available Productive Man-Hours

   - Calculate each retirement time interval's maintainer manpower requirements by MOS and maintenance level. Use the following formula if the Predecessor requirements were developed from R&M data:

$$M_t = \frac{DW \times RSD_t}{AMPH}$$

Where:

M_t = Manpower Requirement (At Time Interval t)

DW = Direct Workload

RSD_t = Retirement System Density (Remaining Number of Systems at Time Interval t)

APMH = Available Productive Man-Hours

- Substitute the appropriate system densities at each time interval. System density is the only variable that will change in subsequent applications of this equation.
- Complete these calculations for each time interval and fiscal year until the Predecessor System has been retired.
- Record the system retirement manpower requirements on Worksheet 2.3-7.

3. **Determine Total Deployment and Retirement Maintainer Manpower Requirements.**

- Use the following formula to calculate the total maintainer manpower requirements by MOS and maintenance level for each interval of the deployment/retirement schedule:

$$M_t = DMR_t + RMR_t$$

Where:

M_t = Manpower Requirement (At Time Interval t)

DMR_t = Deployment Manpower Requirements (At Time Interval t)

RMR_t = Retirement Manpower Requirements (At Time Interval t)

- Record the final manpower requirements on Worksheet 2.3-7.

Procedure 1 Example

The analyst determines the New System deployment requirements as follows:

MOS: 68J

AVIM Direct Workload = $420 \frac{\text{Man-Hours/Year}}{\text{System}}$

Assuming a deployment schedule of 45 aircraft per quarter, the deployment manpower requirement for the 68J, at AVIM, will be:

Deployment/Retirement Time Interval		Calculations
Year 1	Quarter 1	$M = \frac{420 \times 45}{1,423} = 13.28 = 13$
Year 1	Quarter 2	$M = \frac{420 \times 90}{1,423} = 26.56 = 27$
Year 1	Quarter 3	$M = \frac{420 \times 135}{1,423} = 39.85 = 40$
Year 1	Quarter 4	$M = \frac{420 \times 180}{1,423} = 53.13 = 53$
Year 2	Quarter 5	$M = \frac{420 \times 225}{1,423} = 66.41 = 66$

The analyst continues these calculations until New System deployment is complete.

Procedure 2 Example

The analyst determines the Predecessor System retirement requirements as follows:

MOS: 68J

AVIM Direct Workload = $550 \frac{\text{Man-Hours/Year}}{\text{System}}$

Assuming a retirement schedule of 50 aircraft per quarter and a current system density of 900 aircraft, the retirement manpower requirement for 68J, at AVIM, will be:

(continued)

Procedure 2 Example (continued)

Deployment/Retirement Time Interval		Calculations
Year 1	Quarter 1	$M = \frac{550 \times (900 - 50)}{1,423} = 328.53 = 329$
Year 1	Quarter 2	$M = \frac{550 \times (900 - 100)}{1,423} = 309.21 = 309$
Year 1	Quarter 3	$M = \frac{550 \times (900 - 150)}{1,423} = 289.88 = 290$
Year 1	Quarter 4	$M = \frac{500 \times (900 - 200)}{1,423} = 270.56 = 271$
Year 2	Quarter 5	$M = \frac{550 \times (900 - 250)}{1,423} = 251.23 = 251$

The analyst continues these calculations until Predecessor System retirement is complete.

Procedure 3 Example

The analyst calculates MOS 68J's overall requirements at AVIM for each time interval (quarter):

Deployment/Retirement Time Interval		Calculations
Year 1	Quarter 1	$M = 13 + 329 = 342$
Year 1	Quarter 2	$M = 27 + 309 = 336$
Year 1	Quarter 3	$M = 40 + 290 = 330$
Year 1	Quarter 4	$M = 53 + 271 = 324$
Year 2	Quarter 5	$M = 66 + 251 = 317$

The analyst continues these calculations until the deployment and retirement schedule is complete.

Action Step 7: Determine Impact of Combat Damage on Maintainer MOSs

Discussion

In this action step the analyst estimates the total maintenance manpower requirements resulting from both component reliability failures and combat damage caused by enemy weapons. The analyst will use data and analysis results generated by the U.S. Army Logistics Center's (LOGCEN) Manpower Requirements Criteria (MARC) Data Base. to estimate Predecessor System and New System maintainer requirements. As of the date of this publication, data and analysis results exist for some aviation and tracked vehicle systems only.

The analyst uses predetermined combat damage maintenance ratios (MRs) furnished by MOS and maintenance level to estimate Predecessor System combat damage maintenance requirements. The analyst estimates New System combat damage MRs by developing New System Adjustment Factors (NSAF) that reflect all New System characteristics. These adjustment factors are expressed as a percentage increase or decrease in anticipated combat damage maintenance actions (primarily remove and replace). Developing these adjustment factors is a complex process that should be undertaken with help from subject-matter experts (SMEs).

The analyst must understand the limitations involved in estimating combat damage workload and maintainer requirements. First, the basic assumptions of comparability analysis used in this action step are strained when combat damage is considered (see the appendix section entitled "Combat Damage and Estimating Its Effects on Maintenance Manpower Requirements"). Second, all MARC combat damage results are currently based on a European scenario. These results may not be appropriate for systems operating in other theaters because these systems may be faced with different enemy threats and suffer different combat damage. Third, because maintenance ratios are aggregated by MOS and maintenance level, the analyst is currently limited to the MOSs for which combat damage MRs are available. Data may therefore not be available for all New System MOSs.

NOTE

Before proceeding with this action step, the analyst should be certain that 1) this action step has been included in the analysis scope, 2) sufficient data exist to perform the action step's procedures, and 3) he or she has read the appendix section entitled "Combat Damage and Estimating Its Effects on Maintenance Manpower Requirements."

Procedures

1. **Obtain Predecessor System MOS MR Data.**

   - Request Predecessor System combat damage MRs by MOS and maintenance level. This request should be made through the HCM analysis sponsor. The required data are maintained in the MARC data base (available Fall 1988) and can be accessed by Army personnel.

2. **Develop/Obtain Predecessor System R&M-Based MRs by MOS and Maintenance Level.**

   - If the Predecessor System maintainer manpower requirements were obtained from TOEs or the MARC data base, use MARC R&M-based MRs by MOS and maintenance level. Ask for these R&M-based MRs while requesting combat damage MRs.

   - If the Predecessor System maintainer manpower requirements were generated from R&M data, obtain from Action Step 3 each maintainer's total direct R&M-based workload at each maintenance level. Use the following formula to calculate the HCM R&M-based MR for each MOS at each maintenance level:

     $$\frac{DW}{UR} = \text{R\&M MR}$$

     Where:

     DW = Direct R&M-Based Workload
     UR = Usage Rate

3. **Determine Predecessor System R&M and Combat Damage Workload for a Single System.**

   - Use the following formula to determine each MOS's combined workload at each maintenance level:

     $$(\text{CD MR} + \text{R\&M MR}) \times \text{UR} = \text{TW}$$

     Where:

CD MR	=	Combat Damage Maintenance Ratio
R&M MR	=	Reliability and Maintainability Maintenance Ratio
UR	=	Single System Usage Rate
TW	=	Total Workload

4. **Determine Predecessor System Maintainer Manpower Requirements.**

- Use the following formula to determine each MOS's manpower requirements at each maintenance level for a single system:

$$M = \frac{TW}{APMH}$$

Where:

M	=	Manpower Requirement
TW	=	Total Workload (R&M + CD)
APMH	=	Available Productive Man-Hours

NOTE

The analyst initially will estimate manpower requirements for a single Predecessor System. These estimated requirements provide the analyst with a valid benchmark. He or she can subsequently multiply the values for this system by any system density to obtain the aggregate workload, by unit, for the various system densities. The analyst must note, however, that predicting the system density is complex once a combat situation is assumed.

- Assuming fully fielded system densities, use the following formula to determine maintainer manpower requirements for each unit:

$$M = \frac{TW \times SD}{APMH}$$

Where:

M	=	Manpower Requirement
TW	=	Total Workload
SD	=	System Density
APMH	=	Available Productive Man-Hours

- Determine the total system requirements by adding all the unit requirements.

- Record the results on Worksheet 2.3-8.

5. **Determine the Comparison System.**

   - Review the MARC combat damage data base and identify the system that is most similar to the New System. In most cases this system will be the Predecessor System.
   - If the comparison system is not the Predecessor System, use the data collection procedures in Action Step 1 to obtain combat damage data for the comparison system.

6. **Develop Proposed System R&M-Based MRs by MOS and Maintenance Level.**

   - Obtain from Action Step 3 each maintainer's total direct R&M-based workload at each maintenance level.
   - Use the following formula to calculate the HCM R&M-based MR for each MOS at each maintenance level:

   $$\frac{DW}{UR} = R\&M\ MR$$

   Where:

   DW = Direct R&M-based Workload
   UR = Usage Rate

7. **Develop New System Adjustment Factors (NSAFs).**

   - Obtain the comparison system's design *specifications*, equipment configurations, mission requirements, and functional and performance characteristics. If the Predecessor System is used as the comparison system, much of this information will reside in the Predecessor System documents and the New System's Mission Area Analysis (MAA).
   - Obtain available New System documents, e.g., design specifications and equipment configurations. Also obtain the New System's mission requirements, functions, functional requirements, and performance characteristics from Substeps 1.1 and 1.3.
   - Compare the New System's design, mission, functional requirements, and performance characteristics with those of the Predecessor System. Take into account the considerations listed in Table 2.3-3.
   - Based on this comparison, develop New System Adjustment Factors (NSAF) for each MOS at each maintenance level. NSAFs are expressed mathematically as a percentage increase or decrease in estimated combat damage maintenance requirements. The analyst uses the NSAFs and the comparison system combat damage MRs to estimate combat damage MRs for each New System MOS.

Table 2.3-3. Combat-Damage-Assessment Considerations

Factors	Considerations
System Characteristics	Examine the New System's and Predecessor System's inherent protective capabilities against each enemy threat from both a system design/ configuration standpoint and performance capability standpoint; for example, a component's vulnerability due to its location within the system or increases/decreases in system maneuverability and/or speed.
System Missions & Operational Environment	Examine the New System's and Predecessor System's probable exposure to enemy activity and threats. This exposure may change because of the requirement to operate in different mission areas. (These different mission areas will have different enemy threats). Consider the combined forces' mission areas, operational areas, system movements, system posture (defiladed, transient), expected munition types, munition source, expected environmental conditions (inherent, induced), etc.; for example, increased/decreased requirement to operate in combat units.
Enemy Capabilities	Examine changes in enemy threats that will likely affect the New System. Consider enemy technological improvements in target acquisition systems, weapon systems, tactics, and support systems; for example, increased accuracy or range of weapons.

NOTE

A positive NSAF reflects an increase in maintenance requirements due to combat. A negative NSAF reflects a decrease in maintenance requirements due to combat.

8. **Estimate Each MOS's Adjusted Combat Damage MR.**

- Use the following formula to calculate each MOS's estimated MR at each maintenance level:

$$MR \times (1 + NSAF) = CD\ MR$$

Where:

MR	=	Comparison System Combat Damage MR
NSAF	=	New System Adjustment Factor
CD MR	=	Combat Damage MR Estimate

9. **Determine R&M and Combat Damage Workload for a Single System.**

- Use the following formula to determine each MOS's combined workload at each maintenance level for a single system:

$$(CD\ MR + R\&M\ MR) \times UR = TW$$

Where:

CD MR	=	Combat Damage Maintenance Ratio
R&M MR	=	Reliability and Maintainability Maintenance Ratio
UR	=	Single System Usage Rate
TW	=	Total Workload

10. **Determine the Maintainer Manpower Requirements.**

- Use the following formula to determine each MOS's maintainer manpower requirements at each maintenance level for a single system:

$$M = \frac{TW}{APMH}$$

Where:

M	=	Manpower Requirement
TW	=	Total Workload (R&M + CD)
APMH	=	Available Productive Man-Hours

NOTE

The analyst initially will estimate manpower requirements for a single Predecessor System. These estimated requirements provide the analyst a valid benchmark. He or she can subsequently multiply the values for this system by any system density to obtain the aggregate workload, by unit, for the various system densities. The analyst must note, however, that predicting the system density is complex once a combat situation is assumed.

- Assuming fully fielded system densities, use the following formula to determine maintainer manpower requirements for each unit:

$$M = \frac{TW \times SD}{APMH}$$

Where:

M	=	Manpower Requirement
TW	=	Total Workload
SD	=	System Density
APMH	=	Available Productive Man-Hours

- Determine total system requirements by adding all the unit requirements.
- Record the results on Worksheet 2.3-8.

Procedure 1 Example

The New System is a cargo helicopter designated to replace the CH-47 helicopter. Through the analysis sponsor the analyst obtains the following data generated by the U.S. Army LOGCEN.

MOS	AVIM Combat Damage MR	AVUM Combat Damage MR
35K	0.0006	0.0063
35M	0.0004	0.0045
66U	0.0009	0.0090
67U	0.0092	0.0857
68B	0.0008	0.0081
68D	0.0009	0.0090
68F	0.0005	0.0054
68G	0.0073	0.0686
68H	0.0006	0.0521

Procedure 2 Example

In this particular HCM analysis. the Predecessor System's manpower requirements were developed using TOEs and MARC. The analyst therefore uses MARC R&M-based MRs by MOS. These MRs were developed by the LOGCEN.

MOS	AVIM R&M MR	AVUM R&M MR
35K	0.0502	0.2870
35M	0.0540	0.0291
66U	0.0540	1.8515
67U	0.7193	5.9943
68B	0.0119	0.3031
68D	0.0340	0.2092
68F	0.0493	0.2185
68G	0.3844	0.6000
68H	0.0168	0.0521

Procedure 3 Example

The analyst determines the combined annual workload for each MOS at each maintenance level. The single system annual usage rate is 696 hours.

	Combined CD and R&M MR		Total Workload	
MOS	AVIM	AVUM	AVIM	AVUM
35K	0.0508	0.2933	35.4	204.1
35M	0.0544	0.0336	37.9	23.4
66U	0.0549	1.8605	38.2	1294.9
67U	0.7285	6.0800	507.0	4231.7
68B	0.0127	0.3112	8.8	216.6
68D	0.0349	0.2182	24.3	151.9
68F	0.0498	0.2239	34.7	155.8
68G	0.3917	0.6686	272.6	465.4
68H	0.0174	0.0584	12.1	40.6

Procedure 4 Example

The analyst calculates for a single aircraft the Predecessor System's maintainer manpower requirements for each MOS and maintenance level. The Annual Available Productive Man-Hours (AAPMH) for an AVIM unit located at Corps is 2.704: the AAPMH for an AVUM unit located at Corps is 2.298.

	Total Workload		Single System Predecessor Maintainer Manpower Requirements	
MOS	AVIM	AVUM	AVIM	AVUM
35K	35.4	204.1	0.0131	0.0888
35M	37.9	23.4	0.0140	0.0102
66U	38.2	1294.9	0.0141	0.5635
67U	507.0	4231.7	0.1875	1.8415
68B	8.8	216.6	0.0033	0.0943
68D	24.3	151.9	0.0090	0.0661
68F	34.7	155.8	0.0128	0.0678
68G	272.6	465.4	0.1008	0.2025
68H	12.1	40.6	0.0045	0.0177

(continued)

Procedure 4 Example (continued)

MOS	Single Aircraft Predecessor Maintainer Manpower Requirements AVIM	AVUM	Corps (400 Aircraft) Predecessor Maintainer Manpower Requirements AVIM	AVUM
35K	0.0131	0.0888	5.2	35.5
35M	0.0140	0.0102	5.6	4.1
66U	0.0141	0.5635	5.6	225.4
67U	0.1875	1.8415	75.0	736.6
68B	0.0033	0.0943	1.3	37.7
68D	0.0090	0.0661	3.6	26.4
68F	0.0128	0.0678	5.1	27.1
68G	0.1008	0.2025	40.3	81.0
68H	0.0045	0.0177	1.8	7.1

Procedure 5 Example

The analyst identifies the CH-47 (Predecessor System) as the comparison system.

Procedure 6 Example

The analyst obtains Proposed System maintainer direct workload from Action Step 3 and calculates the R&M-based MR for each MOS at each maintenance level:

MOS	Direct Workload AVIM	AVUM	Proposed System Usage Rate	R&M-Based MR AVIM	AVUM
35K	41.1	229.0	1000	0.0411	0.2290
35M	51.8	31.6	1000	0.0518	0.0316
66U	39.9	2134.1	1000	0.0399	2.1341
67U	664.4	3981.2	1000	0.6644	3.9812
68B	21.5	351.0	1000	0.0215	0.3510
68D	27.4	183.8	1000	0.0274	0.1838
68F	64.3	368.1	1000	0.0643	0.3681
68G	299.0	674.4	1000	0.2990	0.6744
68H	11.2	21.6	1000	0.0112	0.0216

(continued)

Procedure 7 Example

The analyst obtains the comparison system's functional and performance characteristics and the New System's mission requirements, functions, functional requirements, and performance characteristics. With this information the analyst considers the factors listed in Table 2.3-3 and works with SMEs from all combat-damage-assessment disciplines (see Appendix A) to develop the following NSAFs:

MOS	NSAF AVIM	NSAF AVUM	Comments
35K	0.0	-0.2	The New System will have modular avionic components designed for removal at AVUM; these components reduce combat damage repair at AVUM.
35M	0.0	0.0	No significant changes.
66U	0.0	0.0	No significant changes.
67U	-0.2	-0.2	The New System will have enhanced capabilities against ballistic attack, thus reducing anticipated combat damage repair at both AVIM and AVUM.
68B	0.1	0.1	Increased engine vulnerability due to New System engine compartment design.
68D	0.0	0.0	No significant changes.
68F	-0.2	-0.5	Increased modularity and incorporation of electro-optics.
68G	0.0	0.0	No significant changes.
68H	-0.1	-0.1	New System design decreases pneudraulic system's vulnerability.

Procedure 8 Example

The analyst applies the NSAFs to the Predecessor System combat damage MRs to determine the adjusted combat damage MRs:

(continued)

Procedure 8 Example (continued)

MOS	Adjusted Combat Damage MR AVIM	AVUM
35K	0.0006	0.0050
35M	0.0004	0.0045
66U	0.0009	0.0090
67U	0.0074	0.0686
68B	0.0009	0.0090
68D	0.0009	0.0090
68F	0.0004	0.0027
68G	0.0073	0.0686
68H	0.0005	0.0058

Procedure 9 Example

The analyst determines the combined annual workload for each MOS at each maintenance level. The single system annual usage rate is 696 hours.

MOS	Combined CD and R&M MR AVIM	AVUM	Total Workload AVIM	AVUM
35K	0.0508	0.2920	35.4	203.2
35M	0.0544	0.0336	37.9	23.4
66U	0.0549	1.8605	38.2	1294.9
67U	0.7267	6.0629	505.8	4219.8
68B	0.0128	0.3121	8.9	217.2
68D	0.0349	0.2182	24.3	151.9
68F	0.0497	0.2212	34.6	154.0
68G	0.3917	0.6686	272.6	465.4
68H	0.0173	0.0579	12.0	40.3

Procedure 10 Example

The analyst calculates for a single aircraft the Proposed System's maintainer manpower requirements for each MOS and maintenance level. The Annual Available Productive Man-Hours (AAPMH) for an AVIM unit located at Corps is 2.704; the AAPMH for an AVUM unit located at Corps is 2.298.

(continued)

Procedure 10 Example (continued)

MOS	Total Workload AVIM	Total Workload AVUM	Single System Predecessor Maintainer Manpower Requirements AVIM	Single System Predecessor Maintainer Manpower Requirements AVUM
35K	35.4	203.2	0.0131	0.0884
35M	37.9	23.4	0.0140	0.0102
66U	38.2	1294.9	0.0141	0.5635
67U	505.8	4219.8	0.1871	1.8363
68B	8.9	217.2	0.0033	0.0945
68D	24.3	151.9	0.0090	0.0661
68F	34.6	154.0	0.0128	0.0670
68G	272.6	465.4	0.1008	0.2025
68H	12.0	40.3	0.0044	0.0175

The analyst now calculates the Corps maintainer requirements based on 400 aircraft.

MOS	Single Aircraft Predecessor Maintainer Manpower Requirements AVIM	Single Aircraft Predecessor Maintainer Manpower Requirements AVUM	Corps (400 Aircraft) Predecessor Maintainer Manpower Requirements AVIM	Corps (400 Aircraft) Predecessor Maintainer Manpower Requirements AVUM
35K	0.0131	0.0884	5.2	35.4
35M	0.0140	0.0102	5.6	4.1
66U	0.0141	0.5635	5.6	225.4
67U	0.1871	1.8363	74.8	734.5
68B	0.0033	0.0945	1.3	37.8
68D	0.0090	0.0661	3.6	26.4
68F	0.0128	0.0670	5.1	26.8
68G	0.1008	0.2025	40.3	81.0
68H	0.0044	0.0175	1.8	7.0

SUBSTEP 2.3
WORKSHEETS

WORKSHEET 2.3-1

Use this worksheet to calculate the maintenance workload for each piece of equipment in the Predecessor System, BCS, and Proposed System.

Configuration: Predecessor BCS Proposed

Equipment Number	Equipment Name	Maintenance Ratios					Scenario Usage Rate	Direct Maintenance Workload				
		Crew	ORG	DS	GS	Depot		Crew	ORG	DS	GS	Depot

WORKSHEET 2.3-2

Use this worksheet to compare the maintenance workload tasks and the training tasks.

Maintenance Workload Task	Paygrade	Training Task	Skill Level

WORKSHEET 2.3-3

Use this worksheet to record the maintainer MOSs' paygrades.

MOSs/ASIs	Paygrades

WORKSHEET 2.3-4

Use this worksheet to assign maintenance workload to each maintainer MOS and each depot.

Equipment Name	Maintenance Level	Direct Workload	MOS, ASI, and Paygrade or Depot

WORKSHEET 2.3-5

Use this worksheet to determine manpower requirements by MOS and maintenance level.

MOS, ASI, and Paygrade: ______________________

Maintenance Level	Direct Workload	APMH	System Density	Maintainer Manpower

WORKSHEET 2.3-6

Use this worksheet to determine each depot's manpower requirements.

Depot: ____________________

Direct Workload	APMH	System Density	Depot Manpower

WORKSHEET 2.3-7

Use this worksheet to determine maintainer manpower requirements for the deployment and retirement time intervals and system densities.

MOS and ASI: ______________________

Depot (if applicable): ______________________ **Maintenance Level:** ______________________

Direct Workload per System: ______________________ **APMH:** ______________________

Time Interval	New System Cumulative Density	New System Maintainer Manpower Requirement	Predecessor System Remaining Density	Predecessor System Maintainer Manpower Requirements	Total MOS Requirement

WORKSHEET 2.3-8

Use this worksheet to document maintainer manpower requirements that reflect both R&M and combat damage workload.

System: Comparison System New System

MOS	R&M MR	CD MR	USAGE RATE	TOTAL WORKLOAD	SYSTEM DENSITY	Maintainer Manpower Requirement		
						ORG	DS	GS

Substep 2.4: Determine Operator/Crew Manpower Requirements

Overview

In this substep the analyst determines operator/crew manpower requirements for the Predecessor System and Proposed System. The analyst uses operator workload, crew maintenance workload, Available Productive Man-Hours (APMH), and system densities to calculate these operator/crew manpower requirements. Figure 2.4-1 is an overview of this substep.

NOTE

> An operator workload analysis may not be required. The need for such an analysis depends on the system being studied. Whether this need exists should have been established during the scoping of the analysis.

Operator workload determination is based on the time required to perform mission events and the tasks that make up these mission events. Because a human-factors analysis is the most accurate way to determine task performance times, the HCM analysis of operator manpower requirements should follow a human-factors analysis.

The analyst determines New System operator manpower requirements by first determining each mission event's operator workload. He or she determines mission-event workload through a detailed task-by-task analysis of sequential and simultaneous task relationships. The analyst uses a task timeline to plot these sequential and simultaneous tasks to determine how long they will take to perform and how many soldiers will be required to perform them.

After he or she has determined the operator workload, the analyst must meet with the training analyst to finalize the MOS selections made in Substep 2.1. The analyst must add the crew maintenance workload (from Substep 2.3, Action Step 1) to the operator workload. He or she then determines APMH and calculates the operator/crew manpower requirements. Once the analyst has determined the direct-workload-driven manpower requirements, he or she must compare these requirements with the minimum prescribed operator requirements. Following this comparison, the analyst determines the final operator/crew manpower requirements. The analyst uses the last action step to determine the operator/crew manpower requirements during deployment and retirement.

The analyst uses the Predecessor System's Tables of Organization and Equipment (TOE) and Basis of Issue Plan (BOIP) to identify operator manpower requirements. When using the TOE, the analyst must be careful to distinguish between system-specific operator positions and non-system-specific operator positions.

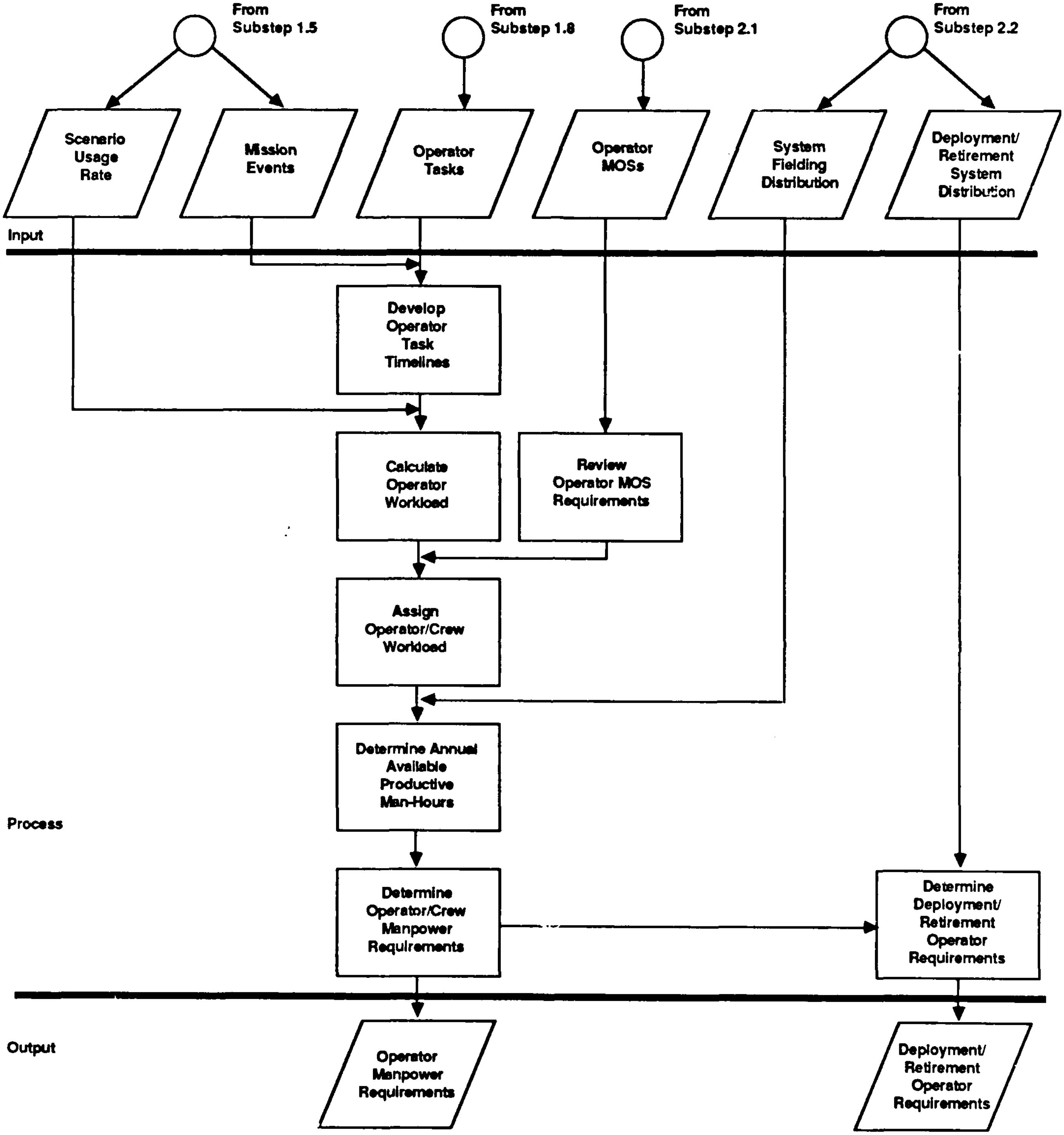


Figure 2.4-1. Overview of Substep 2.4, Determine Operator/Crew Manpower Requirements.

Action Step 1: Develop Operator-Task Timelines for Each Mission Event

Discussion

In this action step the analyst uses technical manuals, soldier's manuals, human-factors-analysis results, Army Training and Evaluation Program (ARTEP) results, and New System documents to develop operator-task timelines for each mission event identified in Substep 1.5.

Mission events are the actions that make up a function. Each event consists of collective and individual workload tasks that must be performed in a particular sequence. The analyst uses task timelines to document each mission event's task sequence.

Procedures

1. **Obtain System Characteristics and Operational Employment.**
   - Use the technical and field manuals for the Predecessor System and other existing/comparable equipment to evaluate the New System's physical characteristics and operational use. Other sources include how-to-fight manuals, training publications, and Logistic Support Analysis Record (LSAR) documentation (for the Proposed System alternatives).
2. **Review and Update the Generic Operator Tasks.**
   - Compare the system information from Procedure 1 with the generic operator task list from Substep 1.8. Update the generic operator-task list to reflect the Proposed System's specific equipment and employment concepts.
   - List the mission events and operator tasks on Worksheet 2.4-1.
3. **Develop Operator-Task Timelines for Each Mission Event.**
   - Categorize the operator tasks as "sequential" or "simultaneous."
   - Plot the sequential and simultaneous tasks using the timeline on Worksheet 2.4-2. Place the sequential tasks in a series (one after another) and the simultaneous tasks in parallel (one on top of another).

Procedure 1 and 2 Examples

The New System is a self-propelled howitzer (SPH). Mission events under the Move function include Displace, Transit, and Emplace. The relevant operational tasks are:

Mission Event	Tasks
Displace	Secure Cannon
	Install Travel Lock
	Secure Tools and Equipment
	Secure Ammunition and Charges
	Secure Cab and Hull Doors
	Displace and Stow Spades
	Start Engine and Release Brake
	Check Ready to Move Out
Transit	Determine Route to New Position
	Drive SPH
Emplace	Locate New Position
	Inspect New Position
	Prepare New Position
	Move and Adjust SPH in Position
	Emplace Spades
	Set Brake and Cut Engine
	Release Travel Lock
	Check SPH Systems
	Determine Mask
	Communicate System and Mission Status

Procedure 3 Example

The analyst determines the task timeline for each mission event. The timeline for the Displace mission event is shown on the following page.

(continued)

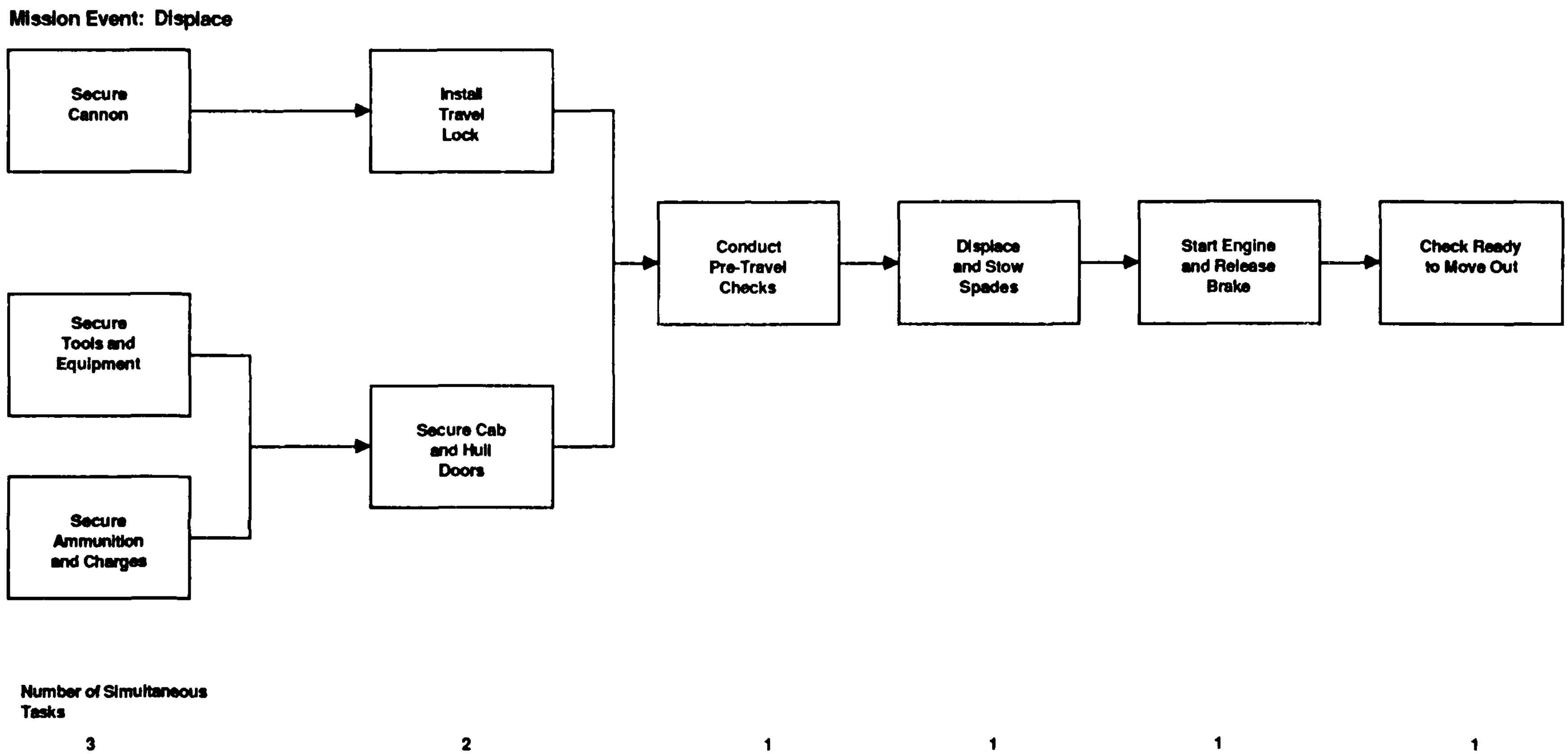


Figure 2.4-2. Operator-task timeline for the Displace mission event.

Action Step 2: Calculate Each Mission Event's Operator Workload

Discussion

In this action step the analyst determines each mission event's operator workload by identifying how long each task in a mission event takes and how many soldiers are required to perform it.

Procedures

1. **Determine Workload Task Data.**

   - Select a mission event.
   - Using standard task-performance data and human-factors-analysis results, determine task-performance times and the minimum number of soldiers required to perform the task.
   - Record the task-performance time and required number of soldiers on Worksheet 2.4-2.

2. **Determine Mission-Event Times and Required Number of Soldiers.**

   - Using the task timelines developed for each mission event in Action Step 1, and the number of operators required for each task, determine the minimum number of operators required to perform the mission event. Examine the simultaneous tasks and select the largest number of operators required simultaneously during the mission event.
   - Using the mission-event task timelines and the task-performance times, determine the time required to complete the mission event.

   NOTE

   The analyst should not simply add all the task times comprising a mission event. He or she should note all sequential and simultaneous task relationships while developing the mission-event time. The time required to perform a mission event depends on the sequential tasks that constitute the mission event's critical path.

3. **Determine Each Mission Event's Workload.**

   - Use the following formula to calculate each mission event's workload:

Mission Event Time	x	Number of Soldiers	=	Mission Event Operator Workload

4. **Determine the Total Operator Workload.**

- Determine the operator workload required for one sequence of mission events by arranging the mission events in operational sequence as described in Substep 1.5.
- Determine how much of the scenario usage rate (miles driven, rounds fired, hours operated) is satisfied by one sequence of mission events. Repeat the sequence of mission events until either the scenario requirement is satisfied or the time available for its completion expires.

Procedure 1 Example

The analyst begins the operator workload analysis with the Displace mission event. Using human-factors-analysis results, the analyst determines the individual task-performance times and the required number of soldiers. The analyst then determines the sequential-task performance times and number of soldiers required. In this example, three tasks are being performed simultaneously in one time period. The analyst selects five minutes as the sequential-task performance time because that is the longest time required to perform any one of the three simultaneous tasks. The operator task timeline is shown on the following page.

Procedure 2 Example

The analyst determines that the minimum number of operators required is four because it is the largest number of operators required simultaneously during the mission event. The analyst then sums the sequential task times to obtain the mission-event performance time. The result is 18 minutes.

Procedure 3 Example

The analyst calculates the operator workload for each mission event. The Displace mission event requires 72 man-minutes. The analyst completes a task timeline for each mission event and determines the following information:

	Transit	Emplace	Fire Mission	Communicate
Minutes	24	10	6	*
Soldiers	2	5	5	1

* The Communicate mission event must be performed continually throughout all possible mission-event sequences.

(continued)

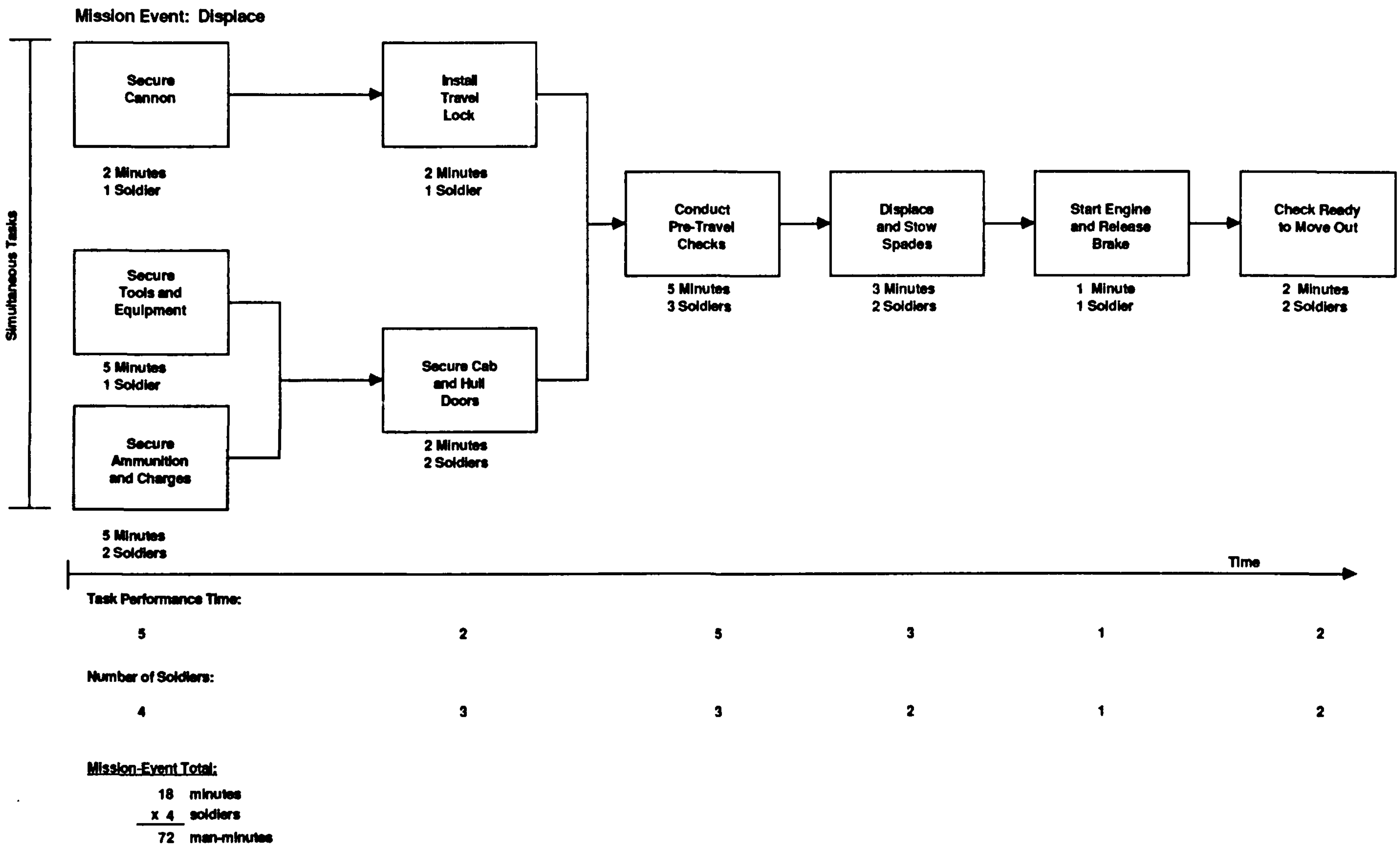


Figure 2.4-3. Operator workload analysis for the Displace mission event.

Procedure 4 Example

The analyst arranges the mission events in operational sequence as shown on the next page.

For all mission events the analyst determines the following results:

Elapsed Time = 18 + 24 + 10 + 6 = 58 minutes
Number of Soldiers = 6

Six is the largest number of soldiers required by this arrangement of mission events: it is therefore the minimum number required for one sequence. The total operator workload is 348 man-minutes (6 soldiers x 58 minutes).

NOTE

> The Communicate mission event requires one operator and is performed continually throughout the mission-event sequence. Therefore, each of the other mission events in the sequence is conducted simultaneously with the Communicate mission event. The number of soldiers required at each interval in the sequence reflects both the Communicate mission event requirement and the corresponding mission event requirement.

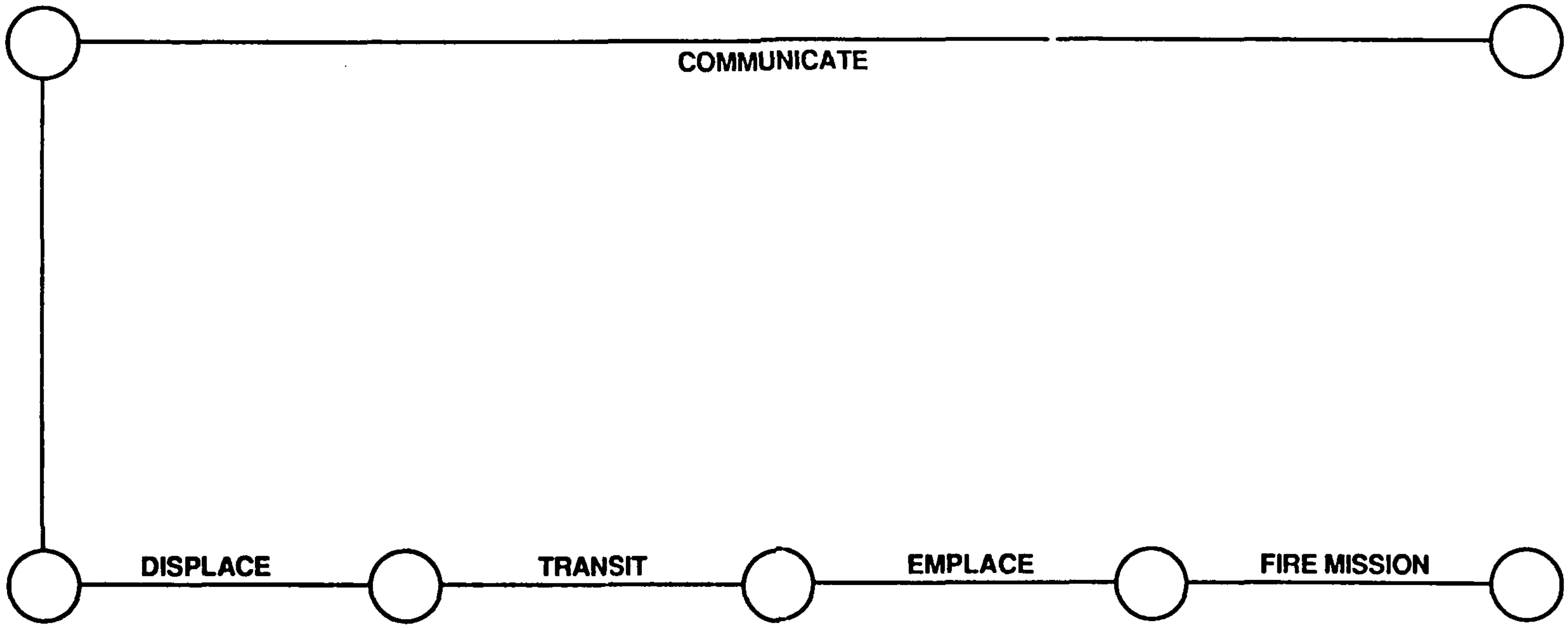
After consulting the engineering analyst, the manpower analyst determines that the most critical mission requirement is to fire 600 rounds per week. During one mission-event sequence, the SPH fires 12 rounds.

The analyst determines the minimum operator workload:

$$\frac{600 \text{ rounds/week}}{12 \text{ rounds/mission event}} = 50 \text{ mission events/week}$$

$$348 \text{ minutes} \times 50 \text{ mission events/week} = 17{,}400 \text{ man-minutes/week}$$

$$\frac{17{,}400}{60} = 290 \text{ man-hours per week}$$



	DISPLACE		TRANSIT		EMPLACE		FIRE MISSION	
Soldiers:								
	Communicate	1	Communicate	1	Communicate	1	Communicate	1
	Displace	4	Transit	2	Employee	5	Fire Mission	5
	Total	5	Total	3	Total	6	Total	6
	18	minutes	24	minutes	10	minutes	6	minutes
	x 5	soldiers	x 3	soldiers	x 6	soldiers	x 6	soldiers
	90	man-minutes	72	man-minutes	60	man-minutes	36	man-minutes

Figure 2.4-4. Mission events in operational sequence.

Action Step 3: Review Operator MOS Requirements

Discussion

In this action step the manpower analyst must meet with the engineering and training analysts to make final operator MOS, ASI, and duty position selections for the Proposed System. The analysts must also determine the operator MOS's skill levels and paygrades.

The training analyst used the initial MOS, ASI, and duty position selections during the training task analysis. In this action step the manpower and training analysts must reconcile any differences between the workload and training tasks for the MOS, ASI, and duty positions. The workload task list may include tasks that the training analyst did not include in the training task list and vice versa. The analysts must determine whether both task lists include every task that must be performed and trained. Task descriptions on both lists should use consistent terminology. During this process the analysts must pay particular attention to any discrepancies between the workload task's skill level and the skill level at which the task is trained. Such discrepancies indicate that a task is being performed in the field at one skill level but is being trained at a different skill level.

Procedures

1. **Compare the Operator Workload Tasks with the Training Tasks and Determine Paygrades.**
   - List on Worksheet 2.4-3 each operator workload task and its paygrade as provided by the reliability and maintainability (R&M) data source.
   - List on Worksheet 2.4-3 each training task and its skill level as provided by the training data source.
   - Determine whether the workload tasks are reflected in the training tasks. Reconcile any differences and update both task lists accordingly.
   - Update the MOS and ASI selections if necessary and record the MOS and ASIs on Worksheet 2.4-4.
   - Evaluate the paygrade of each operator workload task and the skill level of each training task.
   - Determine whether the New System requires changes to the operator MOS's paygrades or skill levels.
   - Record the MOS's paygrades on Worksheet 2.4-4.

2. **Update the Description of the Operator MOS in the Revised Target Audience Description (TAD).**

   - If changes to the existing operator MOS are necessary, update the Revised MOS Description Form in Substep 3.1.

Procedure 1 and 2 Examples

The example in Action Step 1 of Substep 2.1 is continued here. The New System is a replacement for the M1 ABRAMS tank. The manpower analyst determined in Substep 2.1 that a notional MOS, 19XX, will be required for the New System.

The manpower, training, and engineering analysts convene and determine that a new MOS, 19XX, is required to operate the New System. This decision is based on a careful review of the workload tasks, training tasks, and the TAD.

The manpower analyst and training analyst evaluate the paygrade assignments from the R&M and training data sources and determine that no paygrade changes are required.

Action Step 4: Assign Operator/Crew Workload to the Operator MOS, ASIs, and Duty Positions

Discussion

In this action step the analyst assigns workload to the appropriate operator MOS, ASIs, and duty positions. The analyst must combine the operator workload with the crew maintenance workload from Substep 2.3.

Procedures

1. Assign the Operator/Crew Workload.
   - Obtain the mission events and workload tasks from Action Step 1 and record them on Worksheet 2.4-5.
   - Examine each workload task in each mission event and determine the appropriate ASI and duty position for that task.
   - Add the crew maintenance workload from Worksheet 2.3-1 to the operator workload (by ASI and duty position).

Procedure 1 Example

The self-propelled howitzer (SPH) example is continued here. The analyst obtains the workload tasks for the Displace mission event:

Mission Event	Tasks
Displace	Secure Cannon Install Travel Lock Secure Tools and Equipment Secure Ammunition and Charges Secure Cab and Hull Doors Displace and Stow Spades Start Engine and Release Brake Check Ready to Move Out

The analyst examines the workload tasks associated with each mission event and determines the appropriate MOS, ASIs, skill levels, and paygrades:

Duty Position	MOS	Skill Level	Paygrade
Section Chief	13B	3	E6
Gunner	13B	2	E5
SPH Driver	13B	1	E4
Asst. Gunner	13B	1	E3

The analyst obtains the operator workload from Action Step 2 of this substep and the crew workload from Action Step 1 of Substep 2.3. The analyst then assigns this workload to MOS 13B at the appropriate paygrades.

Action Step 5: Determine the Operator MOS's Available Productive Man-Hours

Discussion

The analyst uses the procedures in this action step to determine the operator MOS's Available Productive Man-Hours (APMH). The analyst's principal source of information is Army Regulation 570-2, *Manpower Requirements Criteria (MARC) — Tables of Organization and Equipment.* AR 570-2 provides Annual Available Productive Man-Hours (AAPMH). In this action step the analyst normalizes these AAPMH to the time period for which operator workload was determined.

Chapter 3 of AR 570-2 contains instructions for determining AAPMH by unit. When the analyst determines operator manpower requirements for a given unit, he or she assigns that unit's APMH to the operator MOS.

Procedures

1. **Determine the AAPMH.**

   - Follow the instructions in AR 570-2 for determining the AAPMH for each type of unit in the force structure(s).

   NOTE

   After consulting subject-matter experts on the system's operational environment, the analyst may decide to use non-standard factors to determine AAPMH. This practice is acceptable provided the methods and information are sufficiently documented to support deviation from AR 570-2.

2. **Because Operator Workload Is Calculated for Periods Shorter than a Year, Normalize the Annual Factor to Those Periods.**

   NOTE

   When normalizing to a required unit of time, the analyst should be sure that he or she is dividing by the correct time periods. For example, a week can consist of 5 days (peace time work days) or 7 days (combat working days). Similarly, a year can be thought of as 240 work days or 365 work days. The analyst must be sure that the correct time units are used in all calculations.

- Divide the AAPMH by 365 to obtain daily man-hours.
- Multiply the daily hours by 7 to obtain weekly values (7-day combat week).
- Multiply the daily hours by 30 (30-day combat month) to obtain monthly values.
- Record the MOS's APMH on Worksheet 2.4-6.

Procedure 1 Example

The analyst uses AR 570-2 to determine AAPMH. A radar system in a combat unit (Type Unit Code 1), located at division (Unit Location Code 1), with a one-unit security requirement (Unit Security Code A), and a unit movement requirement of once in three days or less (Unit Movement Code A) yields the following crew AAPMH.

	Section A	Section B	Resulting AAPMH
Crew	3.764	-365	3.399

Procedure 2 Example

The analyst normalizes the AAPMH to obtain daily, weekly, and monthly APMH.

	Annual Value	Daily (Annual/365)	Weekly (Daily x 7)	Monthly (Daily x 30)
Crew	3.399	9.3	65	279

Action Step 6: Determine Operator/Crew Manpower Requirements

Discussion

In this action step the analyst uses workload (Action Step 2), APMH (Action Step 5), system density (Substep 2.2), and minimum operator requirements to determine the system's operator manpower requirements. The minimum operator requirement is the maximum number of operators required to perform any mission event (Action Step 2).

The analyst will need to use rounding procedures in this action step because workload-driven manpower requirements are often fractions. The analyst will use one of two approaches, the "absolute rule" or the "greater than .3 rule." The "absolute rule" states that any fractional requirement, no matter how small, should be rounded up to the next whole number. The "greater than .3 rule" states that any fractional value less than .3 should be rounded down to the nearest whole number. Any value above .3 should be rounded up to the next whole number.

NOTE

The analyst should obtain the Technical Advisory Group's approval before using either rounding approach.

Procedures

1. **Determine the Direct Workload-Driven Operator/Crew Requirements.**
   - List the operator/crew workload by MOS, ASI, and duty position on Worksheet 2.4-6.
   - Use the following formula to determine operator/crew manpower requirements by MOS for one system:

$$OR = \frac{DW \times SD}{APMH}$$

Where:

OR	=	Operator/Crew Requirement per System (Workload Driven)
DW	=	Direct Workload
SD	=	System Density (Set equal to 1)
APMH	=	Available Productive Man-Hours

- Record the direct workload-driven operator/crew manpower requirements on Worksheet 2.4-6.

2. **Determine the Final Operator/Crew Requirements.**

   - Record the prescribed operator requirements on Worksheet 2.4-6.
   - Compare the workload-driven operator/crew requirements (fractional or whole) with the prescribed minimum operator/crew requirements.
   - If the direct-workload-driven operator/crew manpower requirements are less than the prescribed operator/crew requirements, choose the prescribed requirements as the operator/crew requirements.
   - If the direct workload-driven operator/crew manpower requirements are greater than the prescribed manpower requirements, examine the portion of the requirement that exceeds the prescribed operator requirements.
   - Consider distributing the workload to other duty positions. Redistributing workload can cause other operator position requirements to change. The analyst may be able to use this technique to make a closer match between the prescribed and direct operator/crew requirements.
   - Examine the unit operator requirements. The workload associated with non-system-specific unit requirements such as security may be assigned to system operators if the workload does not interfere with system operation. The Army may want to consider assigning this non-system-specific workload to other MOSs within the unit.
   - If operator/crew workload requirements are still greater than the prescribed requirements, choose the workload-driven requirements.
   - Record the final operator/crew manpower requirements on Worksheet 2.4-6.

3. **Determine the Total Operator/Crew Manpower Requirements.**

   - Use the following formula to determine total operator/crew requirements:

$$M = OM \times SD$$

Where:

M	=	Manpower Requirement
OM	=	Operator/Crew Manpower Requirements per System (Either Workload-Driven or Prescribed. Whichever is greater)
SD	=	System Density

Procedure 1 Example

The analyst uses the workload for the SPH developed in Action Step 4 and a unit's APMH to determine workload-driven operator/crew requirements:

Minimum Workload	APMH
290.00 MH/week	65.00 $\frac{\text{MH/Position}}{\text{Week}}$

MH = man-hours

The analyst must obtain the crew size and the total Army manpower requirement. He or she first determines the number of required positions that are workload driven. The analyst selects the greater of the two workloads listed and divides that workload by the positional APMH. The system density is set to one. The analyst obtains the following results:

$$\frac{290 \times 1}{65} = 4.46 \text{ positions}$$

Workload-Driven Crew Size: 4.46 positions

Procedure 2 Example

The analyst concludes that crew size equals six because the minimum number of operators required is greater than the number of workload-driven positions.

Workload-Driven Crew Size: 4.46 positions

Position-Driven Crew Size: 6 positions

Procedure 3 Example

The analyst determines the total manpower requirement based on a total buy of 600 systems.

$$M = OM \times SD$$

$$6 \times 600 = 3.600 \text{ soldiers}$$

Action Step 7: Determine Operator/Crew Manpower Requirements for System Deployment and Retirement Schedules

Discussion

In this action step the analyst determines the operator manpower requirements during New System deployment and Predecessor System retirement. The analyst uses the time interval determined in Substep 2.2 and the operator requirement for one system from Action Step 6. The analyst also uses the deployment and retirement system densities from Substep 2.2 (instead of the steady-state system densities).

Procedures

1. **Determine the Operator Manpower Requirements During New System Deployment.**

   - Use the following formula to calculate the operator manpower requirements for each time interval in the deployment schedule:

     $$M_t = OPR \times DSD_t$$

     Where:

     M_t = Manpower Requirements (At Time Interval t)

     OPR = Operator Requirement per System

     DSD_t = Deployment System Density (Cumulative Number of Systems at Time Interval t)

   - Substitute the appropriate system densities at each time interval. System density is the only variable that will change in subsequent applications of this equation.

   - Complete these calculations for each time interval and fiscal year until the New System has been fully deployed.

   - Record the system deployment manpower requirements for each time interval t on Worksheet 2.4-7.

2. **Determine Retirement Operator Manpower Requirements for the Predecessor System.**

- Use the following formula to determine the operator manpower requirements for each retirement time interval.

  $$M_t = OPR \times RSD_t$$

  Where:

  M_t = Manpower Requirement (At Time Interval t)

  OPR = Operator Requirement per System

  RSD_t = Retirement System Density (Remaining Number of Systems at Time Interval t)

- Substitute the appropriate system densities at each time interval. System density is the only variable that will change in subsequent applications of this equation.

- Complete these calculations for each time interval and fiscal year until the Predecessor System has been retired.

- Record the system retirement manpower requirements on Worksheet 2.4-7.

3. **Determine Total Deployment and Retirement Operator Manpower Requirements.**

- Determine the resulting operator manpower requirements for each interval of the deployment/retirement schedule. Use the following formula to determine the total operator manpower requirement:

  $$M_t = DMR_t + RMR_t$$

  Where:

  M_t = Manpower Requirement (At Time Interval t)

  DMR_t = Deployment Manpower Requirement (At Time Interval t)

  RMR_t = Retirement Manpower Requirement (At Time Interval t)

- Record the final manpower requirements on Worksheet 2.4-7.

Procedure 1 Example

The analyst calculates the deployment manpower requirements for a deployment schedule of 11 self-propelled howitzers per quarter.

Deployment/Retirement Time Interval		Calculations
Year 1	Quarter 1	M = 6 x 11 = 66
Year 1	Quarter 2	M = 6 x 22 = 132
Year 1	Quarter 3	M = 6 x 33 = 198
Year 1	Quarter 4	M = 6 x 44 = 264
Year 2	Quarter 5	M = 6 x 55 = 330

The analyst continues these calculations until the New System is fully deployed.

Procedure 2 Example

The analyst calculates the retirement operator manpower requirements for a retirement schedule of 15 self-propelled howitzers per quarter and a beginning Predecessor System density of 400.

Deployment/Retirement Time Interval		Calculations
Year 1	Quarter 1	M = 8 x 385 = 3.080
Year 1	Quarter 2	M = 8 x 370 = 2.960
Year 1	Quarter 3	M = 8 x 355 = 2.840
Year 1	Quarter 4	M = 8 x 340 = 2.720
Year 2	Quarter 5	M = 8 x 325 = 2.600

The analyst continues these calculations until the Predecessor System is fully retired.

Procedure 3 Example

The analyst now calculates the overall operator requirements for each time interval.

Deployment/Retirement Time Interval		Calculations
Year 1	Quarter 1	M = 66 + 3.080 = 3.146
Year 1	Quarter 2	M = 132 + 2.960 = 3.092
Year 1	Quarter 3	M = 198 + 2.840 = 3.038
Year 1	Quarter 4	M = 264 + 2.720 = 2.984
Year 2	Quarter 5	M = 330 + 2.600 = 2.930

The analyst continues these calculations until the deployment and retirement schedule is complete.

SUBSTEP 2.4
WORKSHEETS

WORKSHEET 2.4-1

Use this worksheet to document operator workload tasks.

Mission Event	Operator Tasks

WORKSHEET 2.4-2

Use this worksheet to develop operator-task timelines.

Mission Event: ______________________

Operator Tasks

Number of Simultaneous Tasks:
Task Performance Time:
Number of Soldiers:

Time

Number of Operators:
Total Task Performance Time:
Mission Event Operator Workload:

WORKSHEET 2.4-3

Use this worksheet to compare the operator workload tasks and the training tasks.

Operator Workload Task	Paygrade	Training Task	Skill Level

WORKSHEET 2.4-4

Use this worksheet to record the operator MOS's paygrades.

MOS/ASIs	Paygrades

WORKSHEET 2.4-5

Use this worksheet to assign the operator tasks to the operator MOS, ASIs, and duty positions.

Mission Event	Tasks	MOS, ASI, Duty Position	Total Operator Workload (including crew maintenance)

WORKSHEET 2.4-6

Use this worksheet to determine total operator/crew manpower requirements.

MOS, ASI, Duty Position	Total Operator/Crew Workload	APMH	System Density	Operator Manpower	Prescribed Operator Requirements	Final Operator Manpower Requirements

WORKSHEET 2.4-7

Use this worksheet to determine operator manpower requirements for the deployment and retirement time intervals and system densities.

MOS, ASI, and Paygrade: ______________________ **APMH:** ______________________

Operators per System: ______________________

Time Interval	New System Cumulative Density	New System Operator Manpower Requirements	Predecessor System Remaining Density	Predecessor System Operator Manpower Requirements	Total MOS Requirements

Substep 2.5: Determine Non-Workload-Driven Manpower Requirements

Overview

In this substep the analyst determines non-workload-driven manpower requirements. There are three types of non-workload-driven manpower requirements: standard positions, as described in AR 570-2, *Manpower Requirements Criteria (MARC) — Tables of Organization and Equipment;* supervisors of direct maintainers, as described in AR 611-201, *Enlisted Career Management Fields and Military Occupational Specialties;* and policy positions, as described in AR 570-2 (aviation) and as dictated by the weapon system or unit to which the system is deployed. Figure 2.5-1 is an overview of this substep.

The analyst uses tables in AR 570-2 to determine standard positions. Standard positions are those positions in which work output is not readily measurable and is not directly related to man-hours worked. These positions are usually based on organizational doctrine: they include prescribed load-list clerks, unit supply personnel, equipment maintenance clerks, food services personnel, etc. Standard positions are determined in the same manner as enlisted supervisor positions and some technical inspector positions, both of which are position rather than workload driven. The analyst should be aware that standard positions can be difficult to identify and are more closely related to the unit, rather than to a system that is assigned to the unit.

The analyst determines policy-driven manpower requirements by studying the system and the units to which it will be deployed. If the system has policy-driven manpower requirements, the analyst must include these requirements in the system's total manpower requirements. The analyst uses the staffing tables in AR 611-201 to determine the number of supervisors the system requires.

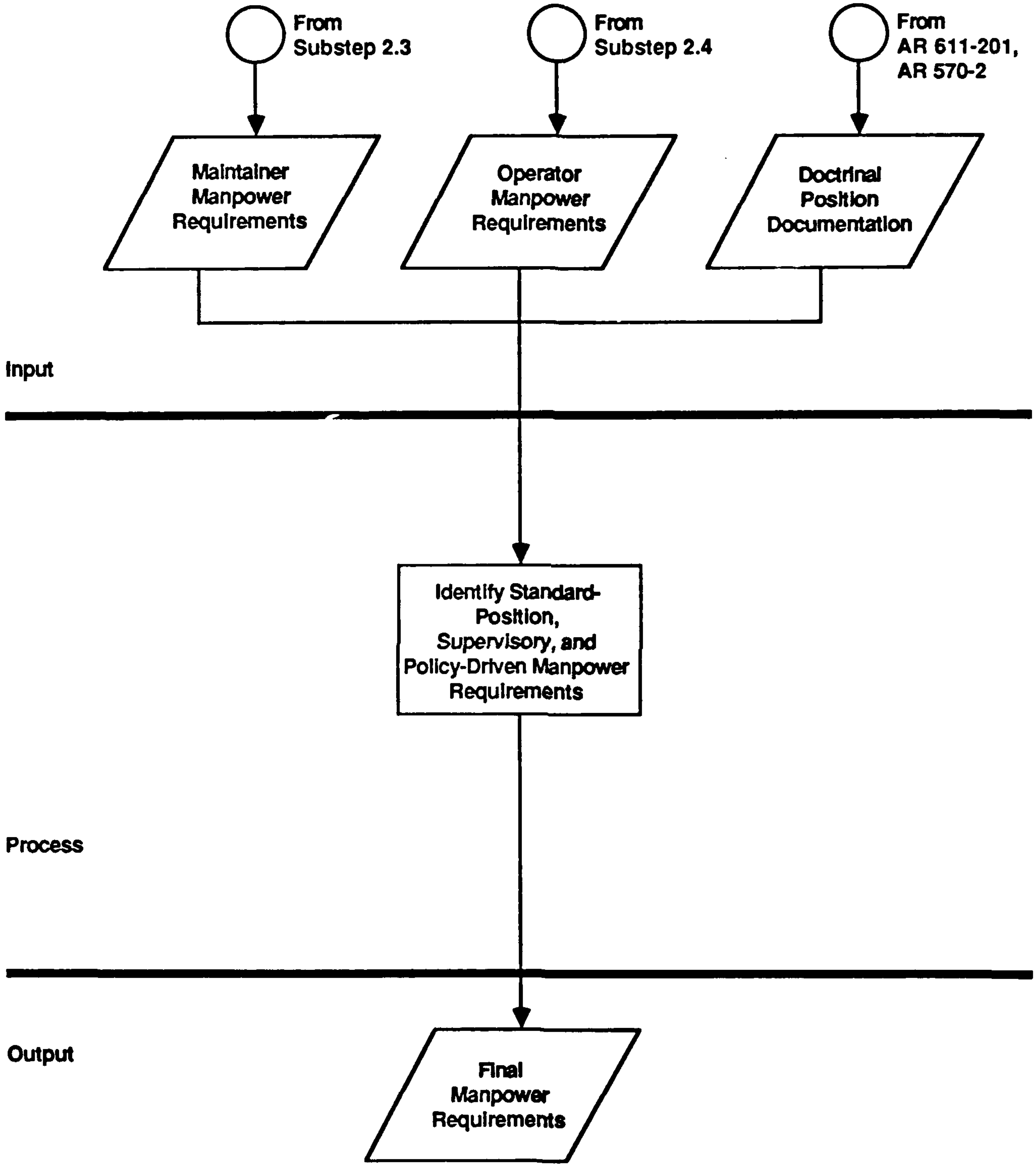


Figure 2.5-1. Overview of Substep 2.5, Determine Non-Workload-Driven Manpower Requirements.

Action Step 1: Identify Standard-Position, Supervisory, and Policy-Driven Manpower Requirements

Discussion

In this action step the analyst determines non-workload-driven manpower requirements based on the workload-driven manpower requirements for the Predecessor System. Baseline Comparison System (BCS), and Proposed System.

Procedures

1. **Calculate the Standard Positions.**
   - Using the detailed procedures provided in AR 570-2 (Chapter 11, Quartermaster and Supply Series, Section I), calculate the required standard positions.
2. **Identify Supervisory Manpower Requirements.**
   - Look up each operator and maintainer MOS in AR 611-201.
   - Refer to the Standards of Grade Authorization (SGA) table and determine the appropriate number of supervisors based on each MOS's workload-driven manpower requirements.
3. **Identify Policy-Driven Manpower Requirements.**
   - Using the Operational and Organizational (O&O) Plan, the Table of Organization and Equipment (TOE), requirements documents, and knowledge of the Army, identify manpower requirements that are policy driven.
4. **Determine Total Manpower Requirements.**
   - On Worksheet 2.5-1, add the non-workload-driven manpower requirements and the workload-driven requirements to obtain the total manpower requirements.

Procedure 1 Example

The analyst must calculate equipment maintenance clerk positions for an Aviation Company with 20 helicopters and 20 or more other systems requiring logbooks (but not more than 28).

The analyst looks in paragraph 11-4 of AR 570-2 and notes that one position is authorized for each Company-size unit maintaining 20 or more equipment logbooks in accordance with The Army Maintenance Management System (TAMMS). When the number of logbooks is less than 20, the analyst may assign the logbook task to appropriate maintenance/clerical positions required by the unit. In this example, two 76C (Equipment Maintenance Clerk) positions are authorized. The analyst adds these standard-position requirements to the workload-driven requirements to obtain the total manpower requirements.

Procedure 2 Example

The analyst must determine the required number of supervisors in an Aviation Company with 15 helicopters. The Proposed System has a manpower requirement of 10 68Js at Aviation Unit Maintenance (AVUM) and 5 68Js at Aviation Intermediate Maintenance (AVIM). The analyst refers to the staffing tables in AR 611-201 and determines that the 10 positions at AVUM generate 2 supervisors: 1 68J30 and 1 68J40. The 5 positions at AVIM generate 1 68J30 supervisor. The analyst adds these supervisor requirements to the workload-driven manpower requirements to obtain the total manpower requirements.

Procedure 3 Example

The analyst must determine policy-driven manpower requirements for an Aviation Company with 15 helicopters. Because Army policy dictates that each helicopter will have a crew chief (in this example a 67U, Medium Helicopter Repairer), this Aviation Company must have at least 15 67Us. Earlier in Step 2, the analyst determined that only 12 67Us were required in this Aviation Company; he or she must therefore add 3 additional 67Us to the manpower requirements. If the Aviation Company had required 30 67Us, 15 would have been designated as crew chiefs and 15 would have been designated as direct maintainers.

Procedure 4 Example

The analyst determines the AVUM manpower requirements for MOS 68J.

	Workload-Driven Requirements		Supervisor Requirements		Total Requirements	
MOS	AVUM	AVIM	AVUM	AVIM	AVUM	AVIM
68J	10	5	2	1	12	6

SUBSTEP 2.5
WORKSHEETS

WORKSHEET 2.5-1

Use this worksheet to document the non-workload-driven manpower requirements.

MOS/ASI	Workload-Driven Manpower Requirements	Non-Workload-Driven Manpower Requirements	Total Manpower Requirements

APPENDIX A: COMBAT DAMAGE AND ESTIMATING ITS EFFECTS ON MAINTENANCE MANPOWER REQUIREMENTS

The Army includes considerations of reliability, availability, and maintainability (RAM) in its evaluations of developmental and fielded systems and in wartime planning. Reliability is typically measured as a failure rate per an appropriate usage unit, e.g., rounds-fired for weapons or miles-traveled for vehicles and the automotive components of weapon systems such as self-propelled howitzers. Maintainability is characterized by the distribution of maintenance actions over maintenance echelons and by the Military Operational Specialties (MOSs) and times required for the accomplishment of those actions. Availability is the proportion of time a system is available for use and includes both reliability and maintainability considerations. RAM characteristics are important considerations in the determination of replacement end items, spare parts, and recovery, transportation and maintenance personnel and equipment needed to sustain required levels of combat availability.

System battlefield vulnerabilities have been estimated and used in Army analyses for many years. The Vulnerability Analysis Division of the U.S. Army Laboratory Command's (LABCOM) Ballistics Research Laboratory (Aberdeen Proving Ground, Maryland) estimates the probabilities that combat systems will be "killed" when damaged by likely battlefield threats. "Kills" are classified according to whether the damage is catastrophic, that is, not economically repairable (K-Kill), or results in a mobility (M-Kill), or firepower kill (F-Kill). Such results are used, for example, in combat simulations or wargames to estimate unit or force strength and effectiveness during enemy engagements.

However, until recently, the Army has not considered the effects of combat damage on the provisioning of spare parts (Class IX Materiel), major subassemblies (Class VII), or on the manpower required to repair combat damage. Sustainability Predictions for Army Spare Component Requirements for Combat (SPARC) is a series of studies begun in 1978. Conducted by the US Army Materiel Systems Analysis Activity (AMSAA) and the Ballistics Research Laboratory, SPARC's objective is to estimate the requirements for Class VII and IX items which result when combat systems are repairably damaged by enemy threat weapons. The three major applications of SPARC results are:

1) To predict those parts that will be damaged in combat to ensure that the parts are included in wartime provisioning calculations, which previously considered only parts that failed due to usage (reliability failures);

2) To improve or otherwise enhance the survivability of parts so frequently damaged, expensive, or both that they cannot be sufficiently stockpiled; and

3) To motivate the development of field expedient repair techniques, tools, and materials that can extend the combat availability of a system for a short but crucial time in the presence of failed or damaged critical components.

SPARC results have important implications for combat provisioning, system development and product improvement programs as well as manpower planning and training for combat.

A SPARC analysis consists of three major steps:

1) Develop a list of system mission essential components (MEC) and a computerized, three dimensional, solid geometry (target) description of the system;

2) Determine the system's most likely and serious battlefield threats;

3) Analytically subject the target description developed in 1 to the effects of the threat weapons identified in 2 and catalog those effects in a computerized database.

Mission essential components are identified by a collaborative effort among SPARC analysts, user representatives (TRADOC), and Army Materiel Command (AMC) representatives responsible for the system's development and readiness support. Essentiality codes in system documentation and Maintenance Allocation Charts should not be used without critical review for their relevance to the SPARC process. Once the MEC are identified, a computerized target description can be developed.

National Stock Numbers (NSN) for parts or assemblies and other data such as the MOSs and man-hours required for part removal/replacement and the maintenance echelon at which those actions are performed may also be included in the target description database.

The most significant threats are usually defined by the intelligence community or can be gleaned from those included in other Army analyses. For example, the TRADOC performs Cost and Operational Effectiveness Analyses (COEAs) using combat simulations. The major threats included in such analyses are generally those that should be included in a SPARC analysis.

A review of Army studies of an armored vehicle indicated that a few direct fire weapons (i.e., tank fired kinetic energy penetrators and tank and infantry fired chemical energy rounds) were largely responsible for its combat damage. Round penetration capability, biases, and dispersions depend on weapon-to-target range. The vehicle studied was expected to be damaged while in two exposure conditions, i.e., fully exposed when in the "attack" and in hull defilade, when on the "defense." SPARC data were generated for a set of conditions defined by combinations of threat weapon, weapon-to-target (vehicle) range, and target exposure. For each condition, a database of SPARC results was developed. The database includes data for each shotline that results in a repairably damaged vehicle. A shotline consists of all MEC damaged by main penetrator or spall fragments from a single round. Shotlines resulting in K-Kills, that is from main penetrator impact of stored ammunition or fuel, are disregarded. Data for each shotline include:

1) shotline probability of occurrence; factors included in the determination of this probability are: the likelihood of being attacked from the azimuth (direction) of this shotline (this probability distribution is usually based on historical combat data); the probability that the point at which the round impacts

the exterior of the system will occur for the weapon-target range, round bias and dispersion, and attacker aimpoint;

2) a list of the MEC destroyed;

3) the maintenance level at which the repair/replacement of parts destroyed in the shotline would be performed; this is usually defined to be the highest level associated the replacement of any MEC on the shotline.

Analogous approaches are taken for cataloging the damage due to other threats. For example, the effects of indirect fire fragmentation threats are measured by "expected fractional casualties" (Ec). Defined for each mission essential component and threat condition. Ec estimates the fraction of the MEC exposed to the threat condition which will be destroyed. The threat condition is characterized by weapon-to-target range, target location error, number of volleys fired, number of rounds per volley, and the fragmentation characteristics of the round being evaluated.

Thus. a SPARC analysis provides a stochastic characterization of the MEC destroyed when a combat system is repairably damaged by prominent battlefield threats. Note, however, that SPARC analyses are scenario independent. To utilize SPARC results to estimate the provisioning or manpower implications of the combat damage to a system of interest in a specific scenario, estimates of the numbers of repairably damaged (and recovered) systems, by threat and "condition", are required. Such estimates are obtainable from Army wargames or combat simulations conducted by several Army analysis organizations. Some background on Army analyses is provided in the following section.

ARMY ANALYSIS - ARMY MODEL IMPROVEMENT PROGRAM

In July 1978, the Under Secretary of the Army directed that a review of Army analysis be conducted. The objectives of this review were to determine what could be done to improve Army analysis, to illuminate key issues, and to recommend solutions to current problems. The findings and recommendations of the group convened to study the problem were published in the "Review of Army Analysis" (also known as the Hardison Report), April 1979. One major topic of this report was the Army's use of computerized combat simulations and models to analyze complex battlefield situations. Group findings included:

1. "Models" have an important role in Army analysis.
2. Many simulation models exist at the four major Army analysis activities {Concepts Analysis Agency (CAA), TRADOC Systems Analysis Activity (TRASANA), the Combined Arms Center (CAC), and the Army Materiel Systems Analysis Activity (AMSAA)}; these models overlap in function yet have little intermodel consistency in the way combat functions are represented and in the databases they use.
3. A management structure should be established to ensure that combat models are used effectively and consistently in Army analyses.

The study group recommended that a hierarchy of models (HOM) be developed and used as the single, authoritative set of Army analysis models. It was recommended that the HOM have the following attributes:

- the models should describe the Army's battlefield operations and represent all battlefield functions and their interdependencies:
- the models must provide for information flow and for consistent combat representation within the HOM;
- three models are required to adequately represent Army levels of organization: force/theater, corps/division, and battalion task force.
- a family of models are required within each level: a production simulation, a research wargame, a training game, and a surrogate model. Surrogate models were envisioned to be quick running analytically derived representations of simulation results, e.g., obtained by regression analysis of simulation input and results.
- a database structure must be established to provide accurate and consistent data to the model hierarchy.

As a result of the study group's recommendations, orders were issued in 1979-80 establishing the Army Model Improvement Program (AMIP), an Army Models Committee, and assigning individual agency/command responsibilities for model development and validation. The major elements of the hierarchy and developing agencies are:

- Force Evaluation Model (FORCEM) - CAA
- Corps-Division Evaluation Model (CORDIVEM) - CAC
- Combined Arms/Support Task Force Evaluation Model (CASTFOREM) - TRASANA[1]

AMSAA was assigned responsibility for the AMIP item/system level database.

A thorough discussion of the AMIP models is beyond the scope of this appendix. However, CAA's theater level model FORCEM plays an important role in the U.S. Army Logistics Center's Manpower Requirements Criteria (MARC) methodology whose results are the basis for the HCM combat damage related maintenance manpower estimates for the Proposed System. Therefore, the brief discussion of FORCEM that follows is intended to provide HARDMAN Comparability Methodology (HCM) users with background necessary for the thoughtful application of the proposed methodology for developing combat damage workload.

FORCE EVALUATION MODEL (FORCEM)

FORCEM is a computerized representation of a conventional theater war that includes combat, combat support, and combat service support. It is fully automated, deterministic, and time stepped in twelve hour increments. FORCEM is now operational at the U.S. Army Concepts Analysis Agency. FORCEM is used in studies to assess the capabilities of current forces (OMNIBUS Studies), to determine the requirements for support forces

[1] Now the TRADOC ANALYSIS COMMAND (TRAC)

(Total Army Analysis - TAA), and to estimate requirements for personnel, supplies such as petroleum, oil and lubrication, and major items of equipment (WARRAMP).

Division combat is not simulated within FORCEM but the model determines the characteristics of "red" forces opposing blue divisions and accesses and uses the results of detailed division level combat simulations. The division level model intended for use with FORCEM is CORDIVEM. However, sufficient results from that model are not available and FORCEM currently uses results from another model, COSAGE (Combat Sample Generator).

The following "units" are represented in FORCEM: C^2 (Command & Control), maneuver, combat service support, communications, intelligence, engineer, artillery, air defense, air control centers, and airbases. Each unit has personnel, supplies, and equipment that can be destroyed or consumed and replenished and can "own" subordinate units.

The CSS functions are represented by a Support Command (SUPCOM) that represents all entities that perform CSS functions. A SUPCOM unit associated with each theater, army, corps, and division performs the following activities:

1. recovery and evacuation
2. maintenance
3. medical services
4. distribution
5. replenishment
6. port operations
7. transportation

In FORCEM, within resource and combat environment constraints, combat damaged or failed systems are recovered, evacuated, and repaired; sick and wounded personnel are treated; replacement equipment and personnel are distributed; and supplies are replenished. Distribution and replenishment functions are accomplished according to priorities set in the command and control module.

The role that FORCEM plays in the U.S. Army Logistics Center's MARC methodology is described in the following section.

OVERVIEW OF MARC METHODOLOGY

The objective of the MARC studies is to forecast maintenance manpower requirements, by MOS, under wartime conditions. FORCEM represents maintenance by ascribing to SUPCOM units a maintenance man-hour capacity per time step. This capacity can be affected, for example, by attrition or the requirement for unit movement. Maintenance is accomplished in the SUPCOM and repaired equipment is returned to units. Equipment waiting in maintenance queues more than a prescribed time may be transferred to higher echelon facilities. FORCEM's predecessor assumed only that equipment in need of repair was returned to duty a fixed interval after entering the maintenance queue. Thus, FORCEM includes a substantially more refined representation of maintenance than was available in previous theater-wide models. However, FORCEM does not include the detail necessary to achieve MARC's objectives.

MARC studies use detailed simulations of maintenance unit activities and workload (combat damaged and failed systems) to estimate the number of personnel, by MOS, required to perform necessary maintenance. The MARC methodology is depicted in Figure 2. It consists of three major sections:

1. Data are gathered on the scheduled and unscheduled maintenance needs of the systems maintained by the unit being evaluated. These data are obtained from the AMC Subcommand responsible for the wholesale readiness support of the system, and if available, from Sample Data Collection (SDC) programs and Field Exercise Data Collection (FEDC) efforts.
2. Data describing the combat damage caused by likely battlefield threats and the maintenance manpower required to effect the associated repairs are obtained. Combat damage data come from the SPARC program and, if available, historical information maintained by the Survivability/Vulnerability Analysis Center (SURVIAC), Wright Patterson Air Force Base, Ohio, are also gathered. TRADOC uses these data to develop combat damage repair packages that specify the average man-hours required, by MOS, to effect repairs necessitated by combat damage for a threat condition. MARC does not consider the manpower requirements for individual shotlines in its analyses. While hundreds of thousands of shotlines are typically developed in an aircraft SPARC analysis, a few thousand work packages are believed to adequately describe the diversity of maintenance actions required. These packages include a probability of occurrence, the MOSs and number of personnel with each and the man-hours needed to effect the required repairs.
3. The third segment of the methodology defines the operational tempo, i.e., equipment usage rates, in the scenario, maintenance personnel availability, and system combat losses over time. Usage rates are obtained from the TRADOC SCORES Scenarios. The numbers of repairably damaged systems are obtained from FORCEM. Finally, data gathered in steps 1, 2 and 3 are used in a stochastic simulation of the maintenance unit being evaluated to estimate its manpower requirements.

The HARDMAN Comparability Methodology described in this document for estimating the maintenance manpower requirements for the proposed system uses MARC results for a baseline system. But, several factors complicate such a comparability analysis and must be considered before the proposed methodology is applied.

1. The HCM assumes that an existing, similarly designed component used in a similar operational environment can be used as a baseline from which the reliability and maintainability of a proposed component can be estimated. However, the physical location of components within a system and the extent to which survivability considerations were included in its design or placement can dramatically affect the frequency at which this component sustains combat damage. A change in this frequency will alter the requirement for maintenance manpower to remove and replace this component.

APPENDIX B: ACRONYMS AND ABBREVIATIONS

AAPMH	Annual Available Productive Man-Hours
AFSC	Air Force Specialty Code
AMIM	Army Modernization Information Memorandum
ANAD	Anniston Army Depot
ARNG	Army National Guard
ARTEP	Army Training and Evaluation Program
AVIM	Aviation Intermediate Maintenance
AVN CO	Aviation Company
AVUM	Aviation Unit Maintenance
ASI	Additional Skill Identifier
BN	Battalion
BOIP	Basis of Issue Plan
CCAD	Corpus Christi Army Depot
CMF	Career Management Field
COMPO	Component
DCSOPS	Deputy Chief of Staff for Operations and Plans
DESCOM	Depot Systems Command
DoD	Department of Defense
DPAMMH	*Direct Productive Annual Maintenance* Man-Hours
DS	Direct Support Maintenance
EIC	Equipment Identification Code
GFE	Government-Furnished Equipment
GRP	Group
GS	General Support Maintenance
HCM	HARDMAN Comparability Methodology
HHT	Headquarters and Headquarters Troop
ID	Infantry Division
LEAD	Letterkenny Army Depot
LOGCEN	U.S. Army Logistics Center
LSAR	Logistic Support Analysis Record
LIN	Line Item Number
MAAD	Mainz Army Depot
MARC	Manpower Requirements Criteria
MFP	Materiel Fielding Plan
MMH	Maintenance Man-Hours
MOS	Military Occupational Specialty
MPT	Manpower, Personnel, and Training
MR	Maintenance Ratio
MTOE	Modification Table of Organization and Equipment

NSAF	New System Adjustment Factor
OM	Operational Manning
O&O Plan	Operational and Organizationai Plan
ORF	Operationally Ready Float
ORG	Organizational Maintenance
PMOS	Primary Military Occupational Specialty
POI	Program of Instruction
POMCUS	Prepositioned Materiel Configured to Unit Sets
QQPRI	Qualitative and Quantitative Personnel Requirements Information
RCAS	Regimental Combat Aviation Squadron
REG	Regiment
ROC	Required Operational Capability
RRAD	Red River Army Depot
SAAD	Sacramento Army Depot
SGA	Standards of Grade Authorization
SME	Subject-Matter Expert
SPH	Self-propelled Howitzer
SQDN	Squadron
TAADS	The Army Authorization Documents System
TAMMS	The Army Maintenance Management System
TAD	Target Audience Description
TAG	Technical Advisory Group
TDA	Table of Distribution and Allowances
TEAD	Tooele Army Depot
TMMH	Total Maintenance Man-Hours
TOAD	Tobyhanna Army Depot
TOE	Table of Organization and Equipment
TRADOC	Training and Doctrine Command
TRP	Troop
TUC	Type Unit Code
ULC	Unit Location Code
UMC	Unit Movement Code
USAR	U.S. Army Reserve
USC	Unit Security Code
WSAP	Weapon System Acquisition Process

APPENDIX C: GLOSSARY

Additional Skill Identifier (ASI) A code added to the specialty/MOS to designate greater specialization (AR 351-1). For example, soldiers with either 11B, 12B, 19D MOS who receive Dragon Gunnery Training are assigned the ASI C2.

Annual Available MOS Productive Man-Hours (AAMPH) (See Individual Work Capacity.)

Army Training and Evaluation Program A Department of the Army publication providing guidance for training and evaluating units. It provides a list of tasks, ranked according to criticality, which must be accomplished by each element of the unit in order for it to accomplish its table(s) of organization and equipment mission. In addition to the tasks, it lists corresponding training objectives, references, conditions for testing and standards which must be attained (AR 310-25).

Baseline Comparison System (BCS) A current operational system, or a composite of current operational subsystems which most closely represents the design, operational, and support characteristics of the new system under development (MIL-STD-1388-1A).

Basis of Issue Plan (BOIP) A plan which indicates the quantity of new or modified equipment planned for each type of organization and the planned changes to personnel and supporting equipment (AR 70-27).

Career Management Field (CMF) A manageable group of related MOS that provides a visible and logical progression to paygrade E9 (AR 611-201).

Comparability Analysis Process by which estimates of the human resource requirements of an emerging weapon system are derived from the known requirements of similar operational systems and subsystems.

Component An assembly or any combination of parts, subassemblies, and assemblies mounted together in manufacture, assembly, maintenance, or rebuild (JCS Pub 1).

Crew Maintenance Maintenance actions that are performed by the personnel whose principal duty is the operation of a system.

Depot Maintenance That maintenance involving the overhaul of economically repairable material to augment the procurement program in satisfying the overall Army requirements and when required to provide for repair of material beyond the capability of general support maintenance organizations (AR 310-25).

Design Differences The differences in design between projected equipment and comparable existing equipment used in the Baseline Comparison System (BCS).

Direct Productive Annual Maintenance Man-hours (DPAMMH) The man-hours used yearly on one or more of the direct productive maintenance tasks for maintenance of an item of equipment. This time includes both scheduled and unscheduled maintenance requirements and is applicable to all maintainable items of equipment for each maintenance level, exclusive of operator and crew maintenance. DPAMMH are sometimes referred to as "wrench-turning," or "hands-on time" (AR 570-2).

Direct Support Maintenance (DS) That maintenance normally authorized and performed by designated maintenance activities in direct support of using organizations. This category of maintenance is limited to the repair of end items or unserviceable assemblies in support of using organizations on a return-to-user basis (AR 310-25).

Doctrine Fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authorized but requires judgment in application (JCS Pub 1).

Duty Position A group of closely related tasks and responsibilities which are normally assumed by one individual (AR 310-25).

Equipment Identification Code (EIC) An alphanumeric coding scheme used to identify specific pieces of equipment. May equate to Functional Group Codes, Work Unit Codes, or Logistic Support Analysis Record numbers.

Equipment Usage Rate A metric value of expected planned usage factors for a system.

End-Item Equipment A final combination of end-item products, components, parts, and/or materials which is ready for its intended use, e.g., ship, tank, mobile machine shop, aircraft (MIL-STD-1388-1A).

Force Structure The composition, by numbers and types of units, of an existing, planned, or programmed force, or of the entire Army (AR 310-25).

Frequency The number of times a task is performed per period of time.

General Support Maintenance (GS) The maintenance authorized and performed by designated Table of Organization and Equipment (TOE) and Table of Distribution and Allowance (TDA) organizations in support of the Army Supply System. Normally these organizations will repair or overhaul material to required maintenance standards in a ready-to-use condition based upon applicable supported Army area supply requirements (AR 310-25).

Individual Work Capacity The available productive man-hours (available for MOS duties). Excludes all non-available time factors such as security, kitchen patrol, work details, messing, casualties, personal needs, and unit movement (AR 570-2).

Line Item Number (LIN) A number identifying the position which end-line equipment or a component thereof holds in the equipment hierarchy.

Logistic Support Analysis Record (LSAR) That portion of LSA documentation consisting of detailed data pertaining to the identification of logistic support resource requirements of a system/equipment (MIL-STD-1388-1A).

Maintainability A system's or component's requirement for maintenance, both planned and corrective, determines its maintainability. Maintainability is a product of the frequency of planned maintenance actions and corrective maintenance actions multiplied by the time these actions take to complete.

Maintainer The specialist(s) responsible for maintaining the system.

Maintenance Level The four basic levels of maintenance (Organizational, Direct Support, General Support, and Depot) into which maintenance activity is divided (DA Pam 700-127).

Maintenance Ratio A measure of the total maintenance manpower burden required to maintain a system. It is expressed as the cumulative number of man-hours of maintenance expended in direct labor during a given period of time divided by the cumulative number of end items' operating hours during the same time (DA Pam 700-127).

Manpower The total demand, expressed in terms of the number of individuals, associated with a system (MIL-STD-1388-1A). That is, the number of individuals in each MOS/ASI, skill level, and paygrade required to operate and maintain a system.

Manpower Requirements Criteria (MARC) The manpower requirements of positions for Army units as defined in AR 570-2.

Military Occupational Specialty (MOS) A group of duty positions that require closely related skills such that a person qualified in one duty position in an MOS can, with *adequate on-the-job training* (OJT), perform in any of the other positions that are at the same level of difficulty.

Mission A clear, concise statement of a task or tasks to be accomplished.

New System (1) The system that is replacing the Predecessor System, and (2) the system that is being studied in a HARDMAN Comparability Methodology (HCM) analysis.

Operational Manning (OM) The number of personnel required to operate a system in an operational environment.

Operational Readiness The capability of a unit/formation, ship, weapon system, or equipment to perform the missions or functions for which it is organized or designed. May be used in a general sense or to express a level or degree of readiness (JCS Pub 1).

Operator The specialist(s) responsible for operating the system.

Organizational Maintenance (ORG) That maintenance authorized for and performed by a using organization with respect to its own equipment (AR 310-25).

Paygrade The statutory paygrade established in the Career Compensation Act of 1949, as amended (ATRM-159 [R1]).

Predecessor System An existing system(s) that is performing mission(s) that will eventually be performed by the New System.

Promotion Rate The rate at which individuals advance from one paygrade to another.

Proposed System An analytic construct used to determine the functional requirements of a New System. It incorporates the technological advances likely to exist before the system's projected initial operational capability date.

Qualitative and Quantitative Personnel Requirements Information (QQPRI) A compilation of organizational, doctrinal, training, duty position, and personnel information. It is prepared for new or improved material systems by the material developer or material acquisition agency, in coordination with the combat developer and trainer (AR 71-2).

Reliability (1) The duration or probability of failure-free performance under stated conditions, or (2) the probability that an item can perform its intended function for a specified interval under stated conditions (MIL-STD-1388-1A).

Scenario A brief description of the theater, environment, and threat factors that are likely to be associated with the system missions.

Skill Level (1) Level of proficiency required for performance of a specific military job, (2) the level of proficiency at which an individual qualifies in the Military Occupational Specialty (AR 351-1).

Standards of Grade Authorization (SGA) Provisions for determining the grades that can be authorized for positions classified in an MOS (AR 611-201).

System The combination of people, hardware, and information that, when interacting as *a whole, is capable of performing a required mission on the battlefield.*

System Density The quantity of systems requiring maintenance and supply support in a unit, group of units, or at a maintenance level. Stated in terms of the Basis of Issue for units.

Table of Distribution and Allowance (TDA) A table which prescribes the organizational structure, personnel, equipment authorizations, and requirements of a military unit to perform a specific mission for which there is no appropriate table of organization and equipment (AR 310-25).

Table of Organization and Equipment (TOE) A table that prescribes the normal mission, organizational structure, personnel, and equipment requirements for a military unit. It forms the basis for an authorization document (AR 310-25).

Target Audience Description (TAD) A description of the quantity, quality, and performance levels of soldiers who operate, maintain, and support a system. The TAD is specific to the Military Occupational Specialty (MOS) and defines the range of qualifications for all relevant physical, mental, physiological, biographical, and motivational dimensions. The TAD indicates how these characteristics relate to each soldier's ability to operate, maintain, and support a weapon system.

Task A unit of work activity that constitutes a logical and necessary step in the performance of a job/duty. It is the smallest unit of behavior in a job that describes the performance of a meaningful function in the job under consideration.

Tradeoff Analysis An analysis conducted among a number of system alternatives. In an MPT front-end analysis, the goal is to determine the alternative that has the least impact on MPT, while still providing performance and availability rates required by the system to accomplish its missions.

Type Unit Code The proper relationship between the organizational design (Combat, Combat Support, or Combat Service Support) of a specific unit, its wartime mission, and its minimum essential wartime personnel requirements. TOE units are divided into three type units as follows:

a. Combat (TUC #1) unit. A specially designed TOE unit whose wartime mission is to close with and destroy the enemy. Units whose mission it is to destroy the enemy in support of ground gaining troops by fire or other tactical support means are normally classified as Cbt (TUC #1) units. Cbt (TUC #1) units normally operate in the forward portion of the active combat area (division area of operation), but may, because of the range of their primary weapons and positioning requirements, operate in the division and corps rear areas.

b. Combat Support (TUC #2) unit. A specially designed TOE unit whose wartime mission is to provide support and assistance of a nontactical nature to Cbt (TUC #1) units. CS (TUC #2) units operate in the combat zone; normally, in the division and corps areas of operation.

c. Combat Service Support (TUC #3) unit. A specially designed TOE unit whose wartime mission is primarily service and assistance to the units (cbt (TUC #1) and CS (TUC #2) operating in the combat zone area and operating agencies of the communications zone. CSS (TUC #3) units function usually in the COMMZ or along the lines of communications thereto and are most often associated with the echelon above corps forces (AR 570-2).

Unit (1) Any military element whose structure is prescribed by competent authority, such as a table of organization and equipment; specifically, part of an organization. (2) An organizational title of a subdivision of a group in a task force. (3) A standard of basic quantity into which an item of supply is divided, issued, or used. In this meaning, also called unit of issue (JCS Pub 1).

Unit Location Identifies the combat area of operation to MARC/TOE/MTOE action officers, (division UL #1), corps (UL #2), or EAC (UL #3) where a specific TOE unit is expected to perform its wartime function. ("UL" is sometimes referred to as the "Logical Region," but for MARC/TOE/MTOE development and to ensure commonality, "UL" is preferred (AR 570-2).

Unit Movement Code Establishes parameters for frequency of move (AR 570-2).

Unit Security Code Establishes the base of security from which a unit operates (AR 570-2).

Workload The amount of work, stated in predetermined work units, that organizations or individuals perform or are responsible for performing (AR 310-25).

APPENDIX D: HCM-MIST CROSSWALK FOR MANPOWER REQUIREMENTS ANALYSIS

A direct translation of HARDMAN Comparability Methodology (HCM) substeps and action steps to the Man Integrated Systems Technology (MIST) models and worksheets is not possible. MIST is not an "automated HCM"; however, it is an automated methodology that uses the same input, performs similar calculations, and generates many of the same products.

The HCM consists of many step-by-step procedures that must be completed sequentially to generate products. MIST, through automation, combines many of these step-by-step procedures. This combination of procedures is possible because MIST performs all procedures involving mathematical computations. In addition, MIST automatically hands off and receives input/output generated by other procedures within the methodology.

MIST is not as complete as the HCM. For example, MIST does not directly determine operator requirements as does the HCM. MIST also does not compute the Standards of Grade Authorizations and is limited in its ability to handle complex force structures.

The following pages contain a description of the links between the HCM and MIST. As explained above, the links are not direct. They indicate areas where similar parameters are being considered.

HCM - MIST CROSSWALK FOR MANPOWER REQUIREMENTS ANALYSIS

Substep	Action Step	Data Elements	MIST Worksheets/Models
2.1	1	• Operator MOSs	• MOS Selection Aid • CMF File
	2	• Maintainer MOSs • Line Item Numbers • MARC Data Base	• MOS Selection Aid • MARC Data Base File
2.2	1	• Steady-State Force Structures	• Acquisition Schedule (SRA011) • Basis of Issue (SRA012)
	2	• Deployment/Retirement System Distribution	• Acquisition Schedule (SRA011) • Basis of Issue (SRA012)
2.3	1	• Direct Maintenance Workload	• Workload (SRA180) • Equipment Usage Rates (SRA179)
	2	• Updated Maintainer MOSs	• Predecessor System Description (SRA080) • Baseline Comparison System Description (SRA101) • New Configuration System Description (SRA121) • MOS Selection Aid • CMF File
	3	• Maintenance Workload by MOS	• Workload (SRA180)

HCM - MIST CROSSWALK FOR MANPOWER REQUIREMENTS ANALYSIS (Continued)

Substep	Action Step	Data Elements	MIST Worksheets/Models
2.3	4	• Available Productive Man-Hours	• Individual Work Capacity (SRA190)
	5	• Maintainer Manpower	• Manpower Requirements Determination (MRD)
	6	• Deployment/Retirement Maintainer Manpower	• Manpower Requirements Determination (MRD)
	7	• Combat Damage Manpower	• None
2.4	1	• Operator Task Timelines	• New System Functional Sequence (SRA060)
	2	• Operator Workload	• None
	3	• Operator MOSs	• Predecessor System Description (SRA080) • Baseline Comparison System Description (SRA101) • New Configuration System Description (SRA121) • MOS Selection Aid (MSA) • CMF File
	4	• Operator Workload by MOS	• None

HCM - MIST CROSSWALK FOR MANPOWER REQUIREMENTS ANALYSIS (Continued)

Substep	Action Step	Data Elements	MIST Worksheets/Models
2.4	5	• Available Productive Man-Hours	• Individual Work Capacity (SRA190)
	6	• Operator Manpower	• None
	7	• Deployment/Retirement Operator Manpower	• None
2.5	1	• Standard Position, Policy-Driven, and Supervisory Manpower	• None

APPENDIX E: HCM MPT DOCUMENTS CROSSWALK FOR PERSONNEL PIPELINE ANALYSIS

The HARDMAN Comparability Methodology, which is an integral component of the Manpower and Personnel Integration (MANPRINT) program, estimates a weapon system's manpower, personnel, and training (MPT) requirements. The HCM can provide valuable MPT information to Army decision makers during the entire weapon system acquisition process.

The HCM can contribute to many Army MPT processes and documents, including:

- Basis of Issue Plan (BOIP)
- Qualitative and Quantitative Personnel Requirements Information (QQPRI)
- System Training Plan (STRAP)
- Army System Acquisition Review Councils (ASARC)
- Logistic Support Analysis (LSA), MIL-STD-13881A
- System MANPRINT Management Plan (SMMP)
- Individual Training Plan (ITP)

The HCM analysis team can make recommendations concerning any of the data elements contained in these documents; however, the Army has final control of the MPT documents. The relationship between MPT documents and the HCM is reciprocal. Depending on the New System's location in the weapon system acquisition process, the HCM analysis team will either obtain information from these documents or produce results that could feed these documents. The HCM analysis results could be viewed as a test of the data in an MPT document. HCM Tradeoff Analysis can be used to consider alternatives.

The HCM MPT documents crosswalk on the following pages lists the products of Step 3 by action step and the MPT documents that require similar information.

HCM - MPT DOCUMENTS CROSSWALK FOR MANPOWER

Substep	Action Step	HCM Products	MPT Documents
2.1	1	• Operator MOSs, ASIs, and Duty Positions	
	2	• Maintainer MOSs and ASIs	
2.2	1	• Steady-State Force Structures	• BOIP, 6D • O&O Plan • TAADS • FAS
	2	• Deployment/Retirement System Distribution	• Materiel Fielding Plan
2.3	1	• Direct Maintenance Workload	• QQPRI, Third Requirement • LSA, Task 401 and 402
	2	• Updated Maintainer MOSs	• QQPRI, Fifth Requirement • BOIP 21a and b • AR611-201 • TOE
	3	• Maintenance Workload by MOS	• QQPRI • TM
	4	• Available Productive Man-Hours	
	5	• Maintainer Manpower	• LSA, Task 303 and 402 • BOIP, 6L • AR611-201 • AR570-2 • TOE • TAADS • QQPRI

HCM - MPT DOCUMENTS CROSSWALK FOR MANPOWER (Continued)

Substep	Action Step	HCM Products	MPT Documents
2.3	6	• Deployment/Retirement Maintainer Manpower	• TAADS • TOE • QQPRI • AR611-201 • Materiel Fielding Plan
	7	• Combat Damage Manpower	
2.4	1	• Operator Task Timelines	
	2	• Operator Workload	• QQPRI, Fourth Requirement • TM • AR570-2 • AR611-201
	3	• Updated Operator MOSs, ASIs, and Duty Positions	• QQPRI, Fifth Requirement • BOIP,21a and b • AR611-201 • O&O Plan • TOE
	4	• Operator/Crew Workload by MOS	• QQPRI, Sixth Requirement • AR611-201 • AR570-2 • O&O Plan
	5	• Available Productive Man-Hours	
	6	• Operator/Crew Manpower	• AR611-201 • AR570-2 • QQPRI, Fourth Requirement • BOIP,6L • O&O Plan
	7	• Deployment/Retirement Operator/Crew Manpower	• Materiel Fielding Plan • TAADS • TOE • QQPRI • AR611-201
2.5	1	• Standard Position, Policy-Driven, and Supervisory Manpower	• AR570-2 • AR611-201 • TOE